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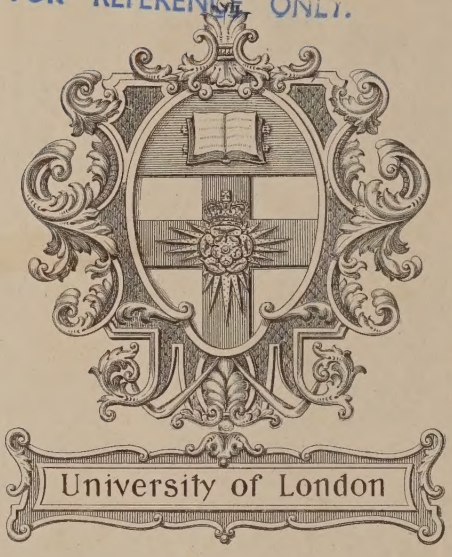

University of London

REPORTS

FROM

COMMITTEES:

THIRTY-TWO VOLUMES.

—*(13.)*—

ACCIDENTS IN COAL MINES.

Session

4 *November* 1852 —— 20 *August* 1853.

VOL. XX.

1852-53.

REPORTS FROM COMMITTEES:

1852-53.

THIRTY-TWO VOLUMES:—CONTENTS OF THE

THIRTEENTH VOLUME.

N. B.—*THE* Figures *at the* beginning of the line, *correspond with the* N° *at the foot of each* Report; *and the* Figures *at the* end of the line *refer to the* MS. Paging *of the Volumes arranged for the House of Commons.*

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FIRST

REPORT

FROM THE

SELECT COMMITTEE

ON

ACCIDENTS IN COAL MINES;

WITH THE

MINUTES OF EVIDENCE,

AND APPENDIX.

Ordered, by The House of Commons, *to be Printed,*
30 *June* 1853.

691.

Martis, 31° die Maii, 1853.

Ordered, That a Select Committee be appointed to inquire into the Causes of the numerous Accidents in Coal Mines, with a view of suggesting the best Means for their Prevention.

Jovis, 2° die Junii, 1853.

Committee nominated of,—

Mr. Hutchins.
Mr. Fitzroy.
Mr. Ingham.
Mr. Hussey Vivian.
Mr. Baird.
Mr. Cumming Bruce.
Mr. Cayley.
Colonel Pennant.
Mr. Stephenson.
Mr. Mostyn.
Viscount Goderich.
Mr. Farrer.
Mr. Child.
Mr. Henry Austin Bruce.
Mr. Cobbett.

Ordered, That the Committee have power to send for Persons, Papers, and Records.

Ordered, That Five be the Quorum of the Committee.

Jovis, 9° die Junii, 1853.

Ordered, That Viscount Goderich be discharged from further attendance on the Committee, and that Mr. Locke be added thereto.

Lunæ, 27° die Junii, 1853.

Ordered, That the Committee have power to Report the Minutes of Evidence taken before them from time to time to The House.

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FIRST REPORT.

THE SELECT COMMITTEE appointed to inquire into the Cause of the numerous ACCIDENTS in COAL MINES, with a view of suggesting the best Means for their Prevention, and who were empowered to Report from time to time to The House,—

HAVE made progress in the Matters to them referred, and have agreed to Report the Minutes of Evidence taken before them.

30 *June* 1853.

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MINUTES OF EVIDENCE.

Lunæ, 13° *die Junii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Mostyn.
Mr. Fitzroy.	Mr. Farrer.
Mr. Hussey Vivian.	Mr. Child.
Mr. Baird.	Mr. Cobbett.
Mr. Cayley.	Mr. Locke.
Mr. Stephenson.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Joseph Dickinson, Esq., of Manchester, called in; and Examined.

J. Dickinson, E

13 June 1853

1. *Chairman.*] YOU are a Government Inspector of Mines?—Yes.

2. Have you been so since the first appointment of inspectors after the passing of the Act?—Yes.

3. For what district are you inspector?—My present district is Lancashire, Cheshire and North Wales.

4. Is that the district of which you were inspector when you were examined before the Committee in 1852?—It is the same district, but the Staffordshire district was formerly a portion of my district. The South Wales district was also entrusted to my care for about four months, during the vacancy occasioned by the resignation of Mr. Blackwell.

5. Have you been recently engaged, with Mr. Mackworth, on a mission of inspection?—Yes.

6. By whom were you sent?—Lord Palmerston.

7. What countries were you instructed to visit?—Belgium, France, and Germany.

8. You visited those countries?—We did.

9. What is the common system of working in Belgium?—The common system of working is long work: the seams are very much contorted and twisted about; so much so, that the working in the same seam sometimes overlaps; but whether the seam lies perpendicular or horizontal, the same system is adhered to.

10. Will you describe the system of long work?—Long work is carried on in Belgium; and it is done by the ordinary system practised in this country, of taking all the coal away at first, and keeping up the waggon roads through the gob. There is scarcely an instance in Belgium where the levels are driven out to the extremity, and the coal worked backward; they get a better quality of coal by working the coal forward, and it is done at a cheaper rate.

11. Is it difficult to carry on ventilation under that system?—There is difficulty in carrying it on unless the gob is packed very tightly, and the sides of it clayed to prevent leakage through the gob; but where the run is short this is not found insuperable in practice. In fire-damp mines, in my opinion, the proper way is, to drive out the galleries to the extremity of the mine, and to work the coal backward, as this ensures a permanent air-way at all times; but where the run is short, there is seldom much difficulty in getting sufficient air to the face of work, the roof settles down on the gob, and presses it tight.

12. As a practical system, the way to work long work would be to carry the air-ways through the gob?—That is the system generally resorted to. I do not consider it the best in fire-damp mines.

13. Is there any difficulty in keeping the gob free from leakage?—Where

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13 June 1853.

the run is short, and the sides are well clayed, the difficulty is seldom found insuperable in practice.

14. Supposing a seam should be perpendicular, is the same system pursued?—Yes.

15. Is there much difficulty in that case?—Not any difficulty.

16. Mr. *Stephenson.*] When the inclination of the seam is very great, you would not recommend the system of driving out to your boundary, and working backwards?—In a fire-damp mine I should recommend it, whether the seam was perpendicular or horizontal.

17. How would you confine the gob in a perpendicular seam, where it would be above your head?—You timber the level, and put brushwood on the top of it, and lay the gob on the top of the timber and brushwood.

18. You say that in Belgium the system of working backways is not adopted; is that system adopted when the seam is nearly perpendicular?—With very few exceptions, they drive all the coal before them in Belgium, and leave the gob behind, supporting the gob by timber and brushwood.

19. When a seam is nearly horizontal, in your opinion, the better way would be to drive out to the boundary and work backwards?—Yes.

20. But in Belgium, they work forwards towards the boundary, taking away the coal?—Yes.

21. What is the length of face which is taken?—It depends on the inclination, to some extent; about 30 yards is the average.

22. Not more?—Not more; that is the average depth.

23. When the inclination is very great, supposing fire-damp to exist in a mine in great abundance, do you prefer the plan of going to the boundary, in consequence of the lightness of carburetted hydrogen, which will always ascend from the working face into the gob, and there remain at rest?—I see no greater difficulty in ventilating a mine with air-ways in the solid coal than with air-ways maintained by gobbing. You have no liability to leakage, if you have the air-ways in the solid coal; but if the air-ways depend on gobbing, there is a liability to leakage through the gobbing, which is avoided by driving out the level to the extremities, and working the coal backward.

24. You overcome the difficulty by keeping them tight?—Yes.

25. *Chairman.*] Is not the roof falling attended with great danger?—No; it is not attended with unusual danger.

26. Supposing there is not enough rubbish to fill the gob, how do they proceed?—In the thin mines, there is generally sufficient rubbish.

27. Have you seen the work in thick mines?—I have seen it in every description of mine; all the mines in Belgium are thin.

28. Supposing it should happen that there be not sufficient rubbish to fill the gob, how would you proceed?—In the south of France the thick coal, which varies in thickness up to 65 feet, is worked by long work. The usual system is, to work eight feet on the bottom in the ordinary way; and as the mine seldom makes sufficient rubbish to fill up the whole of these workings, the rubbish is brought from the surface. After the first working of eight feet, there is another working a few yards behind; and these successive workings, one above the other, are filled up with rubbish, either from the mines, or brought down the pits from the surface. The thick coal of Staffordshire, also, is worked long work. It has been worked long work in two ranges, of about five yards each, for between 20 and 30 years, at Mr. Forster's works at Shut End, near Dudley; and also for some years in Mr. Gibbon's colliery, at Shut End; and it has recently been introduced into the colliery of the New British Iron Company, at Corngreaves. It seems to be a great improvement on the old system of working the thick coal in Staffordshire; and it is worthy of remark, that in no instance that I have heard of, where long work has been introduced, has that system been abandoned, and the old system resorted to. I have examined the working in the thick coal mines of a great number of the principal establishments in Staffordshire, and I think that a more unminer-like system of getting this ten-yard coal than the old systems, which are still commonly practised, it is impossible to see. It is working in a series of unsightly caverns; the men are perched high on scaffolding and ladders, and they are at work underneath the sides, which are overhung many yards beneath the roof, which is liable to fall, and cannot be supported. Indeed the workmen are brought up to it from their childhood, and they may be compared to soldiers in a campaign, for sudden deaths are perhaps as common in the case of the one as in the other. If all

the

the casualties in thick coal collieries were enumerated, I believe that the annual list would outnumber the killed and wounded in a general engagement.

29. *Chairman.*] As a general rule, do you think the system of long work is efficacious?—There is generally no system so efficacious as long work.

30. Is more coal got by it?—All the coal is obtained by it, and the ventilation is much simplified.

31. Mr. *H. Vivian.*] Has not a modified system of long work been adopted in the north of England?—Long work is common in the Midland counties, as far west as Shropshire.

32. Has not a modified system of long work been recently adopted in the north of England, with great success?—In some collieries it has.

33. Will you describe the system of long work?—Long work consists in breasting away extensive ranges of the seam in one working.

34. *Chairman.*] On that system you cannot go down to the dip?—The great secret of success is to keep the packing well built, and close up to the face of work, and not attempt to breast down to the dip, which would throw the weight of the superincumbent strata upon the face of the work, and make it dangerous for the men, and would also crush the coal.

35. In beginning the system of long work, is not the first weight that comes on attended with very considerable danger?—The first weight is generally a dangerous weight; in the course of a few days after the first subsidence has taken place, the roof subsides regularly behind, and there is no more difficulty.

36. Are the men aware of their danger at first?—Yes.

37. Do they work when the roof is settling down?—They sometimes abandon that portion of the work, until the first subsidence has taken place; and where long work has been attempted to be introduced into new collieries, by persons who did not understand it, when this first weight has been coming on, which is the critical weight, the system of long work has frequently been abandoned; had they waited until the subsidence had taken place, their efforts might have been successful.

38. In your district, is the coal worked by long work at all?—We have isolated cases of it in Lancashire and Cheshire, and it is very common in North Wales.

39. And in Shropshire?—In Shropshire it is common, and also in Staffordshire.

40. In South Wales?—In South Wales it is met with in rare cases.

41. Is it as well done, in the districts in England in which you have seen it, as it is in Belgium?—Quite.

42. And the ventilation is sufficiently carried on?—Yes.

43. Is it applicable to South Wales?—It is applicable to the South Wales coal field, as a general rule; its introduction there, I believe, would be the means of reducing the cost of getting the coal, and it would save the immense loss which takes place in pillars under the present system. It is peculiarly applicable to the ironstone mines.

44. Supposing you were working in a seam of 30 feet, how would you proceed?—The system of working the Staffordshire thick coal is, by first working the top half of the seam.

45. How much of the first lift is removed?—They work about eight feet long work, and they breast backward over the gobbing, in getting the main portion of the seven feet.

46. In your opinion, is long work the cheapest and best, and applicable to thick and thin seams of coal?—It is.

47. Is it also better for the carrying on of ventilation?—Yes.

48. In all cases?—There may be exceptional cases; but, as a general rule, it is so.

49. Mr. *Cayley.*] Could the system of long work be applied to mines which are already established?—In most cases it might be applied to the present mines; but perhaps not in all.

50. Would it entail great expense, if it were applied to old mines?—In some cases; but the great difficulty is with the workmen; they are not accustomed to the system, and they are very loath to begin it in their old age.

51. Is it more applicable to deep or to shallow shafts?—I do not think it makes any difference. It is equally applicable to the one as to the other.

52. Is the system of long work universal in the north?—It is not so universal in the north, except in Scotland.

53. You say it is better for ventilation; in what respect is it better?—In working

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working pillar and stall work, you leave a great number of galleries open, and all those galleries require to be ventilated. With long work you have simply the working face open; you leave an in-take gallery for the air to go in; it then passes up the face of work, and returns by the return drift; whilst in pillar and stall work you have a number of galleries, which require to be ventilated.

54. You have no splitting of air?—Yes; you may split the air at different faces of work; you may have one or you may have ten faces of work going on in the same pit; and you can split the air, if it is desirable, in proportion to each face of work.

55. Mr. *Locke.*] Is there any difficulty in splitting the air?—None.

56. Do you find any inconvenience at all?—None.

57. Then where is the difference in pillar and stall work, as to its more efficient means of ventilation, if there is no difficulty in splitting the air?—You have a greater number of galleries to ventilate in the one case than in the other.

58. You do not think the splitting of air is an objection to the mere transmission of air?—It is impossible to ventilate a large colliery properly without splitting the air.

59. Where is the increased difficulty in ventilation by pillar and stall work, as compared with long work?—In the one case you have a larger number of galleries to ventilate than you have in the other.

60. Still the area would probably be the same?—The distance over which air travels in long work is shorter than that which it travels with pillar and stall work, because you have only the in-take gallery and the face of work, and the return air course to ventilate; there is no intricate working in the midst of the colliery to be ventilated, as there is in pillar and stall work; consequently the air has not to be coursed through.

61. Does your objection apply to the increased distance which the air has to travel, or to the intricacy of the course?—It applies to both.

62. *Chairman.*] Do you keep the gas penned up, or do you clear it out?—As a general rule, the gob is not ventilated.

63. Mr. *Stephenson.*] In explanation of an answer which you gave just now, respecting the comparison between the ventilation of long work and the ventilation of pillar and stall work, in splitting the air in pillar and stall work have you not a number of doors to employ?—Yes.

64. Those doors being left open, may leave any one or more of the stalls foul?—Yes.

65. In long work there is simply a current of air going from the down-cast shaft to the face of the work, running along the face of the work, which is only a channel about six or seven feet wide, perhaps, and returns (as you have said) by a drift to the up-cast; that is the simple mode of ventilating long work?—It is.

66. With the pillar and stall work, if you have 20 stalls, you may split the air into four parts, each current of air, or each one-fourth, having to course through four stalls, with a door between each four stalls; is not that the usual mode?—It is.

67. Independent of splitting the air, you have to course up and down the stalls, and therefore each current of air has to pass up one half of the stall and down the other?—Yes.

68. In that case, is not the resistance to ventilation materially increased?—No doubt of it.

69. Must not a greater force be applied to secure good ventilation on the stall system, as compared with the long work system?—Undoubtedly.

70. Is there not also the risk of doors being left open?—Certainly.

71. In the other case there is no risk of that kind?—No; because there are no doors, except there be main doors, to leave open.

72. I am speaking now of the face of the work; I am quite aware there are doors required in other parts of the mine, but they would equally be required on the stall system?—Yes.

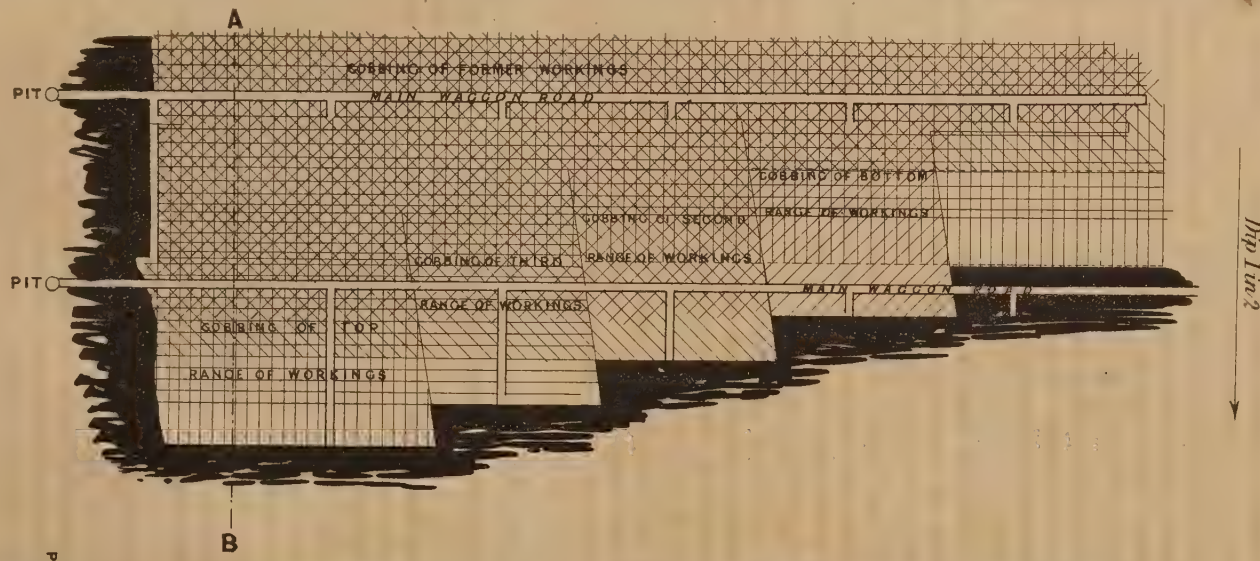
73. And, therefore, where the face of the coal has usually given vent to an enormous quantity of gas, there are no contingencies arising out of doors?—Such contingencies are very much fewer than in pillar and stall-work; the air is all passing up in the particular places where it is required.

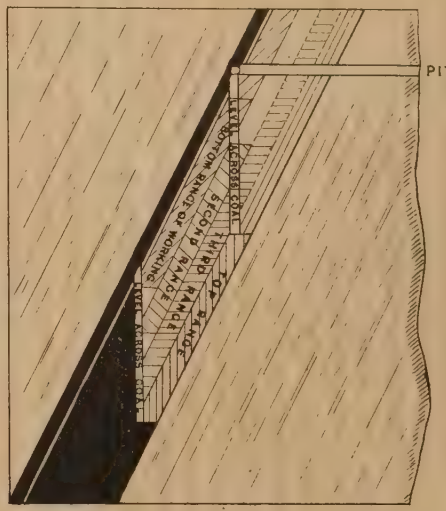
74. *Chairman.*] Therefore it sweeps the face of the coal, and all behind it is so tightly packed up, that the air cannot get into it at all?—Generally it is.

75. Therefore

SKETCH OF A METHOD OF WORKING THE GREAT BED OF COAL AT St ETIENNE IN FRANCE.

The Seam varies in thickness up to 65 Feet, and is worked Long Work, in heights of about 8 Feet each, commencing at the bottom of the Seam. The lower ranges of work are kept in advance of those above, and when the workings do not produce sufficient rubbish for packing the Gob, the necessary rubbish is taken down the pits from the surface. The workings are liable to spontaneous combustion, to avoid which, the Waggon Roads are driven below the Main Seam, so as to admit of their being isolated from any part of the workings should spontaneous combustion take place.





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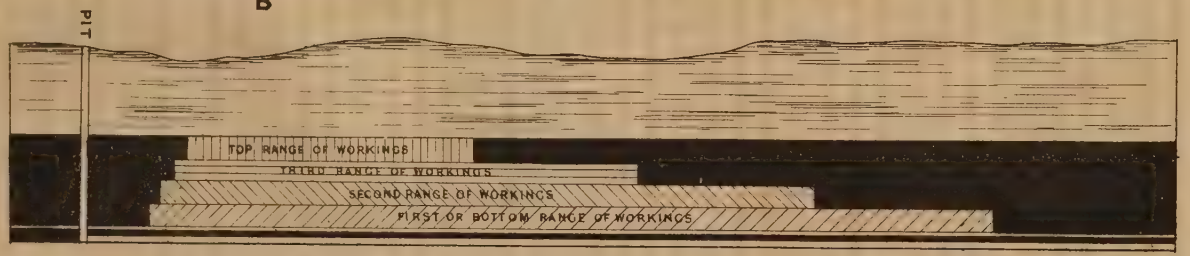

SECTION.

M. W. T. Scott, Mine Surveyor, 24 Great George St. West.

Joseph Dickinson
Inspector of Coal Mines
June 1853

[To face Page 5.]

Dark & Son, Lith. to the Queen

No 691. Ordered by The House of Commons to be Printed 30 June 1853. Henry Hansard, Printer.

75. Therefore the whole current sweeps up where the men are at work out of the main level. Is that so?—Yes.

76. Mr. *Stephenson.*] You have stated that the long work system is, in all cases, more economical and safe than the pillar and stall system. Are you aware that the success of the long work system depends very much upon the character of the roof?—It is frequently stated to depend on the character of the roof; but I think I have seen coal, with almost every kind of roof, worked successfully by long work; and many persons work long work with both good and bad roofs. In the case of working the thick coal of Staffordshire, where the top part of the seam is worked first, and there is nothing but the old gob for the roof of the second working, Mr. Gibbons, who is an authority on these matters, having worked the coal for several years under the system, says he prefers a bad roof to a good one.

77. If the roof be a very good one, is it according to your experience, a very bad plan to introduce the long work system?—If you have a hard, solid rock for a roof, which will not break, it is very apt to crush your coal; and it would be attended, perhaps, with more danger than would otherwise be met with, if you had a tender roof.

78. Have you ever seen a roof in a coal mine, consisting of what is called in the north, post roof or white sandstone, which is almost peculiar to the coal fields of Durham and Northumberland, and is sometimes eight or ten fathoms in thickness?—Yes; there is also a much harder rock which is called quor, in South Wales.

79. Under such a post roof, have you seen the long work system practised successfully?—I have seen a modified system of long work practised very successfully under a quor roof. It is not the ordinary system of long work, but it is called long work in South Wales; it is by driving a stall, eight yards wide, and bringing back the same width of pillar. All the coal is obtained in that working, and perhaps it is the only successful working of coal which there is in South Wales. All the rest, under the bad roofs, is attended with a very considerable sacrifice of pillars.

80. Mr. *H. Vivian.*] Under a roof of that kind, do you conceive that the ordinary long wall system of working could not be carried out?—I do not think that it is so desirable to introduce long work under such a roof, and perhaps it is not in every case practicable. Under good roofs there is seldom any loss of coal by the pillar and stall system, so that no improvement could be effected in economy, or in the clean working of the coal.

81. Do your remarks apply especially to the cleanness of working out the coal, rather than to the ventilation of the mine?—My last remarks apply especially to the cleanness of working, but generally they apply equally to the ventilation.

82. In a 12-feet seam of coal, where the roof falls up to a certain point and arches itself, and does not fall so that the bottom meets the top, how would you support the roof?—You are speaking of pillar and stall working.

83. I am speaking of long wall working?—I have got a drawing of a system which I examined in the South of France, showing the mode of working in a thicker seam than you have described.

[*The Witness delivered in the annexed Drawing.*]

84. In a 12-feet seam of coal, where the roof does not fall to a sufficient extent to support the superincumbent strata, in what way would you deal with long wall work?—I know the South Wales seams very well, having been engaged upwards of seven years in the largest colliery there; but I do not know one where, if you took away the whole of the coal, the roof would not come down behind on your packs.

85. I am now working a colliery to a large extent in South Wales, where the roof will stand for months without falling completely. If it were necessary to support the ground behind the workmen, which is necessary in long wall work, the men would be for months exposed to falls of roof; in that case, could long wall work be carried out except in a modified degree?—Can you describe the sort of roof?

86. It is for some distance a plate roof?—That would work very well long work.

87. I have gone over the goaf myself when the coal has been worked for months, and the roof has not fallen, up where the pillars have all been taken out?—It is a general rule that the plate is one of the best roofs for working long work.

88. It bends rather than breaks at first?—I think that long wall work would be quite applicable to such a roof as you describe.

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89. Would you work the upper or the lower portion first in long wall-work?—In Staffordshire the usual way is to work the upper portion, but I think the best way is to work the lower part first, taking care to pack the gob very tight with rubbish.

90. How would you commence the long work system?—I should keep the lower levels in advance of the upper; for you generally find that if you attempt to keep the upper levels in advance of the lower, there is a tendency to throw the weight of the roof on the face of the work, which makes it more dangerous for the men, and also has a tendency to crush your coal.

91. Assume that your pit is sunk to the bottom of the seam, and that you have to consider how you will commence your work; where would you start your drifts?—As the weight always tends to the dip, I would start them so as to keep the lowest drifts rather in advance of the upper, and throw the weight of work on the gob, and not on the face of the work.

92. Would you start two drifts on the level course and two to the rise?—After opening the pit, and getting the ventilation connected between the down-cast and the up-cast, if it were not a fiery mine, I should breast all the coal forward, carrying the airing along the deepest level, and bringing it back along the upper level.

93. You would work it straight before you?—Yes.

94. In that case, you would not, as in the first instance you recommended, drive out to the extent of your boundary?—If it were a very fiery mine I should recommend driving out the galleries to the extremity, and work backward instead of forward.

95. *Chairman.*] So that all the gas would be left behind you?—Yes; and you would be always sure of maintaining the ventilation by having the galleries in solid coal, and not subject to leakage through the gob.

96. Mr. *H. Vivian.*] You would take the breast of coal forward?—Yes.

97. Then you would leave the gob behind you?—Exactly.

98. Are not goaves very dangerous things, from the gas constantly oozing in enormous quantities from the roof?—An imperfectly ventilated goaf is about the most dangerous thing you can have in a colliery, that is, where the fire-damp is mixed with enough fresh air to bring it to the explosive point; when the goaves are not at all ventilated the fire-damp in them is generally too pure to be explosive, and I have known cases where a goaf which has been full of fire-damp has fired along the edge, where it has been mixed with fresh air; but there not being sufficient air with the fire-damp in the goaf, it has merely been an explosion for the width of a yard or two along the edge; a goaf of that kind is less dangerous than a goaf partially ventilated, until it has arrived at an explosive state. Most goaves admit of being entirely ventilated, but if this cannot be done, the ventilation of them should not be attempted.

99. On your principle of working, you would, after you had sunk your pit to the seam of coal, work your breast of coal right forward, leaving the goaf between you and the pit?—That is the ordinary system.

100. That is the system you recommend?—Yes, where there is not fire-damp, and where the run is short.

101. *Chairman.*] You consider, with regard to the ventilation of the goaves, that it is necessary either to ventilate them thoroughly, so as to clear out the whole of the fire-damp, or not do it at all?—Yes.

102. Mr. *Cayley.*] Is it not true of the whole of the mines generally, that before the system of ventilation was improved, as it has been of late years, in consequence of there not being a sufficient admixture of atmospheric air, explosions did not take place?—Badly as some of our coal mines are ventilated, there are very few which are in such a state as that.

103. When a mine is in a very foul state, it may not be explosive, from the non-admixture of a sufficient quantity of atmospheric air?—In all the coal mines I was ever in, I never, except after an accident, met with a case of that kind, where, in the working galleries of the mine, there was sufficient gas to become explosive if more air were admitted.

104. As a scientific principle, is it true equally as regards the mine as the face of the gob?—Yes.

105. The air may be so foul that it is not inflammable?—No doubt of it.

106. In that state, is it capable of respiration?—No; when you get into a strong admixture of fire-damp you cannot respire it. I had a case, in my district, of two men being suffocated by inhaling a strong admixture of fire-damp.

damp. The effect on the pulse is to quicken the pulse; I have tried my own pulse before going in: it was at 78 on entering this admixture of fire-damp, and after being in for a few minutes, it ran up to 84; I tried a manager's pulse, and it ran up from 80 to 84; I tried the fireman's pulse, and it was at the very unusual height of 120, and it ran up to 126. A person is only enabled to remain in the gas a few minutes, otherwise he must have fallen down, and his breathing would soon stop.

107. Was that gas explosive?—At the edges it was explosive.

108. Was it intermixed with atmospheric air?—Yes.

109. In order to be explosive, what proportion of admixture is required?—I should think that, generally, an explosive mixture is one part of gas and seven of air.

110. When does it cease to be explosive?—I think at about 15.

111. Fifteen parts of atmospheric air to one of fire-damp?—Yes.

112. When there are only three or four parts of atmospheric air to one of foul gas, does it cease to be explosive?—There is not sufficient air for it to become explosive.

113. At what point does it become explosive?—I think it is about one part of gas to three or four of air.

114. Then so far as explosions are concerned, a mine is in the safest condition, when it is so full of a deleterious gas that there is not air enough to explode; or when the amount of ventilation is so great that even when the foul air is mixed with it, it ceases to be explosive?—I should only apply that, with the reservations which I have stated, to the goaves; as to the mine being in such a state as to have the galleries filled with a larger proportion of gas to atmospheric air than would be explosive, as I have said, I do not think there is such a thing to be met with in the country; and I do not recollect ever having met with such a badly ventilated colliery as that.

115. Mr. *Fitzroy.*] Would it be possible for a man to exist under such circumstances?—No; besides, there must be a point where the air, coming down the down-cast pit, and travelling along the workings, and intermixing with this gas in the galleries, it must be explosive.

116. Mr. *Cayley.*] With respect to goaves, where there is any change in the pressure of the atmosphere, is it not the fact that at that time the gas will ooze out of the goaves, when it does not under an ordinary state of the atmosphere?—There is no doubt that with a falling barometer there is a greater liability to explosion than with a rising barometer. I think it is more a subject of interest than of importance. According to Brande, 96·6 of atmospheric air expands to 100 cubic inches, on the barometer falling from 30 to 29 inches. A fall of the barometer, therefore, of only one inch, would have the effect of increasing the volume of the air to the extent of between three and four per cent.; and in addition to this diminution in the density of the air, which is tantamount to a diminution in the quantity, the fire-damp would be liberated more freely from every pore of the strata; and whatever fire-damp existed in the goaves, or in any other part of the workings, it would become expanded in the same ratio as atmospheric air, and the surplus would be discharged into the workings.

117. Is it not a fact, that the only way in which you can account for some of those explosions, which are attended with such fearful calamities, is, that they are occasioned by some change in the barometric pressure?—Taking the number of explosions which have happened in my district, there is, perhaps, a larger proportion to be noticed as having occurred in the summer months, with the increase of temperature from winter to summer; but this is by no means a very great difference; and even with the falls of the barometer, it is very difficult to trace out any connexion with the explosion. I have gone over the whole of the accidents which have happened in my district during the last year, which was a very peculiar year for atmospheric changes; there were very great variations in the barometer and in the thermometer; we had an earthquake in South Wales in the spring, and we had an earthquake in North Wales and Lancashire in the autumn; the fall of rain was great, and there was much thunder; and with all these peculiarities it is very difficult to say that there is any connexion between explosions and atmospheric changes. I have a Diagram, which I beg to hand in, of every explosion which has taken place in my district during the year 1852. It shows the days on which the explosions took place, the variations of the barometer, taken three times per day, the

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variations of temperature, and the difference between the wet and dry bulb of a thermometer, and the daily fall of rain. The first explosion, at Norley Hall colliery, took place when the barometer was rising; the second took place when the barometer was at its summit; the third took place when the barometer was rising. (*The Witness delivered in the same.*)

118. As a general rule, is it not the weight of the atmospheric air, which is going down the gallery, which keeps the foul air back in the goaves?—As I have stated, a fall of an inch in the barometer would make a difference of between three and four per cent. in the quality of the air transmitted through the workings.

119. If it is the weight of the atmospheric air which passes by the face of these goaves which keeps back the foul air, if there is any alteration in the weight of the air, would it not allow the foul air to escape from the goaves naturally?—The foul air, and any other gas, under a diminished pressure, would become expanded in the same ratio as atmospheric air, and would consequently be liberated into the ventilation.

120. It becomes explosive, unless the ventilation be sufficient to produce a sufficient admixture of atmospheric air?—No doubt of it, unless the ventilation is sufficient to render it non-explosive.

121. *Chairman.*] You were understood to state, that the great point in successfully working the long work, is to have the gob so closely packed that no foul air can escape from it?—You cannot always do that; but with a properly ventilated colliery, the ventilation ought always to be such as to sweep away any discharge of fire-damp from the goaves. The temperature of the atmosphere, which has not received the same attention in regard to its connexion with explosions in coal mines, appears to have as important an effect on explosions as atmospheric pressure. According to Brande, air dilates at the rate of $\frac{1}{480}^{th}$ of the volume which it occupied at 32° for every degree of Fahrenheit's scale, and all other aëriform bodies expand in the same ratio. A variation of temperature, therefore, of only 10°, from 60° to 70°, would have the effect of expanding the air, and of making a difference of about two per cent. in the diluent quality of the air through the workings; and if there be fire-damp in the mines, either in goaves or other accumulations, and they be increased in temperature, the fire-damp which they contained would also be expanded in the same ratio, and the surplus would be discharged into the working; but a daily variation of 20° or more degrees are common, and they would make a difference of five per cent. in the virtual quantity of air circulated through the working.

122. Mr. *Cayley.*] Will you explain on what principle that occurs?—It is the principle of expansion; all bodies expand by heat; air expands by heat.

123. Fire-damp and atmospheric air both expand by temperature increased; why is the change likely to be a cause of danger in the mine?—Supposing you had a ventilation of 100,000 cubic feet of air per minute running through your working, at a temperature of 60 degrees, and the external temperature increased from 60 to 70, and you still had 100,000 cubic feet of air per minute running through the workings, that air, by the expansion which had taken place in the increase of temperature, would be expanded at the rate of two per cent., which would reduce the virtual quantity of air to 98,000 cubic feet, although you had the same number of cubic feet per minute running through the workings. 98,000 cubic feet of air at a temperature of 60° would neutralise as much fire-damp as 100,000 cubic feet of air at 70°.

124. Mr. *Stephenson.*] That is, assuming the velocity to remain the same?—Yes.

125. Mr. *Cayley.*] Then the increase in the temperature diminishes the amount of the ventilation?—Yes, as I have described; and with increased external temperature, if the ventilating power be rarefaction, as by the common furnace, or if there be no ventilating power at all (as is too common), a further diminution in the quantity of air circulating through the workings might be looked for, consequent upon external temperature approximating to the temperature of the rarefied column of the up-cast shaft, and thus lessen the balance of power which gives motion to the whole current.

126. You have stated that in the spring time there is a tendency to an increase in the number of accidents?—I said there was a tendency to accidents; it is perhaps perceptible, but it is barely perceptible, if there is an increased number.

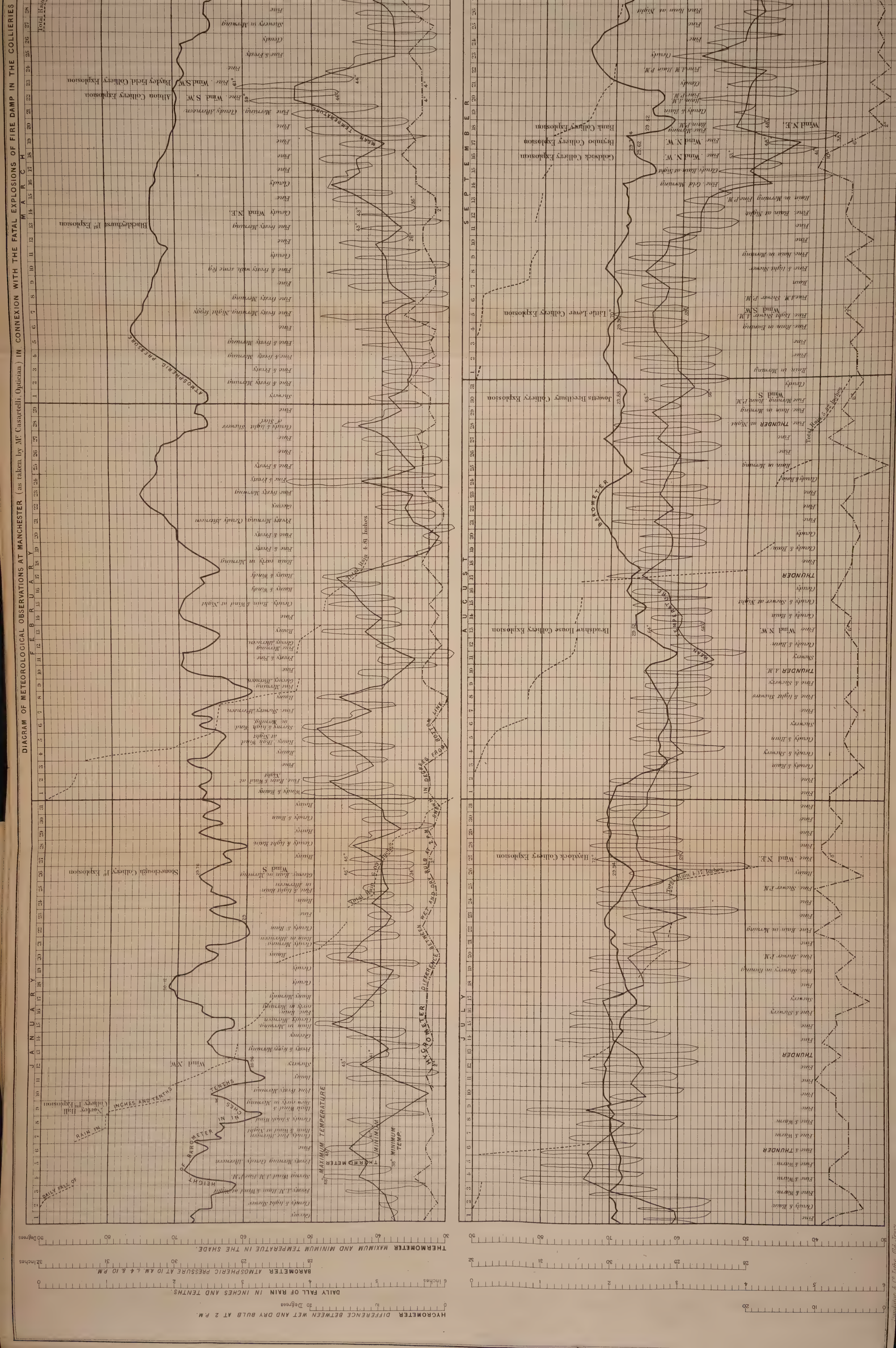
DIAGRAM OF METEOROLOGICAL OBSERVATIONS AT MANCHESTER (as taken by Mr Casartelli, Opticaan) IN CONNEXION WITH THE FATAL EXPLOSIONS OF FIRE DAMP IN THE COLLIERIES
JANUARY
FEBRUARY
MARCH
JULY
AUGUST
SEPTEMBER
Total Rainfall 4·81 Inches
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Total Rainfall 1·5 Inch
Total Rainfall 1·6 Inch
Total Rainfall 1·7 Inch
Total Rainfall 1·8 Inch
Total Rainfall 1·9 Inch
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LANCASHIRE, CHESHIRE AND NORTH WALES, DURING THE YEAR 1852. BY JOSEPH DICKINSON, COVERNMENT INSPECTOR OF COAL MINES, MANCHESTER.

APRIL

Smithfield Explosion
New Tree Colliery Explosion
Hulton Colliery Explosion
Norley Hall 2nd Explosion
Dobsinfield Colliery Explosion
Rain 0.96 Inches
30.09
30.16
29.39
29.36
Wind S.W.
Wind E.

MAY

Hyde & Gerards Bridge Explosion
Gospall Colliery Explosion
Birket Bank & Shand Lane Explosions
Broad Oak Colliery Explosion
Rain 1.56 Inches
29.56°
29.32
29.77
29.64
Wind W.
Wind N.E.

JUNE

Sankey Brook Colliery Explosion
29.55
Wind S.W.
Rain 0.56 Inches
BAROMETER
THERMOMETER
MEAN TEMPERATURE

OCTOBER

Worsley Colliery Explosion
29.52
Wind S.W.
Rain 3.79 Inches

NOVEMBER

Winstanley Colliery Explosion
Stonyclough 2nd Explosion
Platt Lane Colliery Explosion
29.52
28.87
29.13
Wind N.E.
Wind S.E.
Wind N.E.
Rain 2.53 Inches
BAROMETER
THERMOMETER
MEAN TEMPERATURE

DECEMBER

Blackleyhurst 2nd Explosion
Peadlebury Colliery Explosion
29.22
28.89
29.42
Wind S.E.
Wind S.E.
Rain 5.21 Inches
BAROMETER
THERMOMETER
MAXIMUM
MINIMUM
HYGROMETER

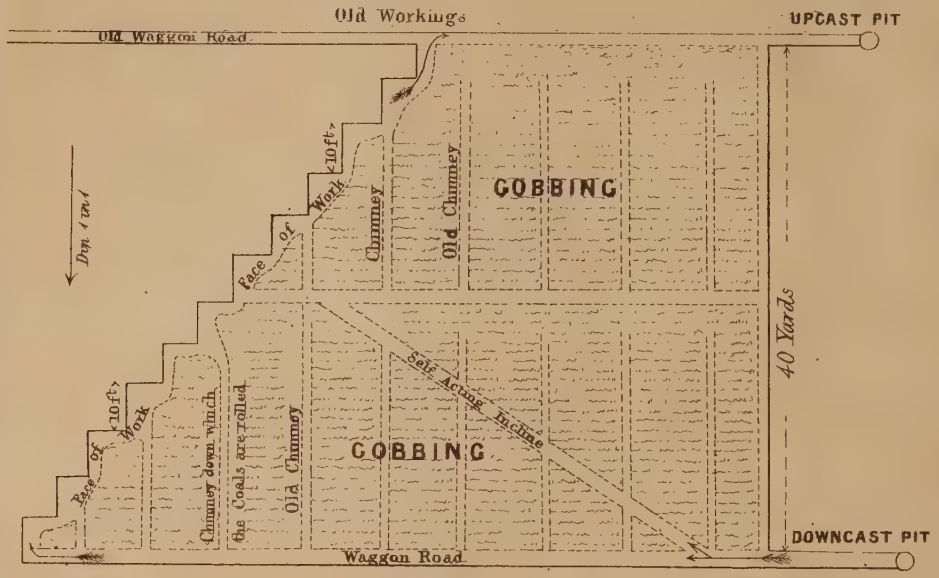
[To face Page 9.]

SKETCH OF LONG WORK IN THE STEEP COAL SEAMS IN BELGIUM.

No 1.

Plan of Workings in a Seam 18 inches thick and dipping 1 in 1.

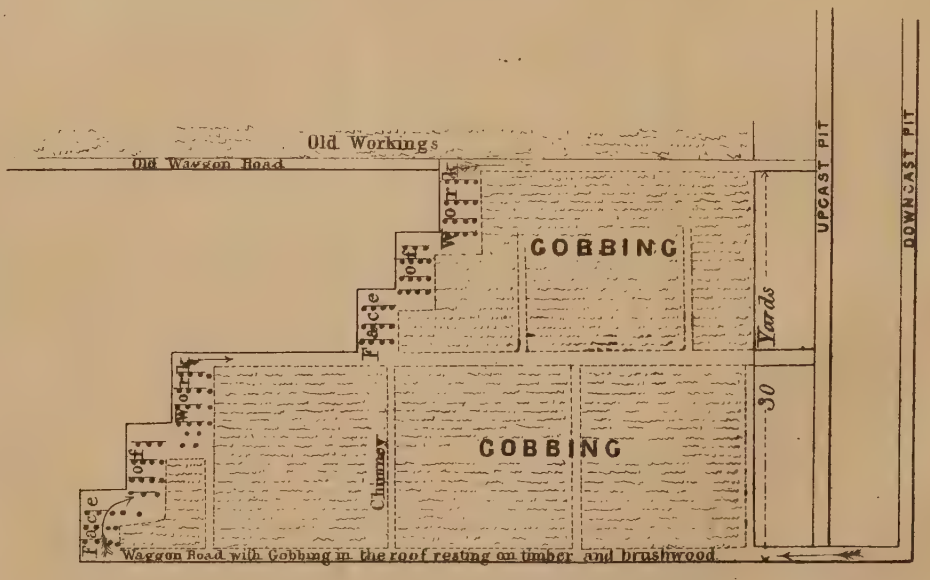
The face of Work is divided into 12 small faces, each 10 feet in length and each of which is one man's place of work. The men work horizontally, and the Coals are rolled down to the Waggon Road through openings in the gob, called Chimneys.



No 2

Section of Workings in a Seam dipping perpendicular.

The perpendicular Seams are worked off platforms resting upon stays fixed into the sides of the Seam. The men work horizontally in faces about 5 yards high, & the Coals are dropped down to the Waggon Road.



Joseph Dickinson
Inspector of Coal Mines
June 1853.

Day & Son, Lith.rs to the Queen
Henry Hansard, Printer.
No 691. Ordered, by The House of Commons, to be Printed, 30th June 1853.

127. Does the liability to that state of things apply equally to natural ventilation, and to any artificial ventilation arising from rarefaction?—Undoubtedly; the latter objection applies to all artificial ventilation arising from rarefaction. It does not apply to mechanical ventilation.

128. Mr. *Locke*.] If the volume of air passing through the mine remained the same, would your objection still be applicable?—Yes, as regards expansion; but I was speaking of the effect which it would have upon the approximation of external temperature to that of the rarefied column in an up-cast shaft.

129. *Chairman*.] Can you, by the next meeting of the Committee, prepare a drawing of the system of long work as practised in Belgium?—Yes.

130. Mr. *Locke*.] Will all the evidence you have given this morning on the question of long work be applicable to the diagram you are going to furnish to the Committee?—I will endeavour to make the drawing apply to it all.

131. What are the means of ventilating in Belgium?—Mechanical appliances are very common in Belgium, and they appear to be on the increase. In 1845 there were 35 ventilators at work, and in 1849 they had increased to 64, and others have been erected since. The average steam power to each in 1849 was nine horses.

132. Are there any other means?—Yes; the furnace is sometimes resorted to. A great number of mines in Belgium, France and Germany are carried on by natural ventilation only.

133. Mr. *Fitzroy*.] Describe some of those mechanical processes to which you refer?—There are seven different varieties. The first is that of Mr. Fabrey; it is a mechanical arrangement, and has two shafts revolving in contrary directions, with three vanes fitted to each shaft, with the effect of isolating the return air, and discharging it. The second is Mr. Letoret's, which is the common fan.

134. Mr. *Locke*.] For exhausting air?—Yes, they are all exhausters; to Mr. Letoret's there are four arms; the arms are not carried out at right angles to the full distance; at about half the diameter they are bent back at an angle of 110°. The third is Mr. Pasquet's; it is on the principle of the revolving chimney top; it has hitherto been made with three vanes, but a large one is being now constructed with six vanes. Mr. Pasquet has also a ventilator similar to Mr. Fabrey's. The fourth is Mr. Lessoine's, which is similar to Mr. Pasquet's, but has more vanes. The fifth is Mr. Motte's, on the principle of the Archimedean screw. The sixth is the piston; this is similar to Mr. Struve's, in this country.

135. Mr. Sturve's drawing was before the Committee of 1849?—Yes; the piston differs from Mr. Struve's in being single-acting, and in having the valves horizontal instead of nearly vertical. Mr. Struve's also works in water, which prevents leakage. A ventilator of this kind has been at work near Liege for 18 years, without a break down.

136. Mr. *Cayley*.] Do you mean without any failure in the machinery?—Without any important failure. The seventh is Mr. Lamielle's; this is a new ventilator; there is only one of the kind at work. It consists of a revolving hexagonal cylinder, the sides of which are opened and shut by an excentric, and by which means the air is isolated and thrown out.

137. Are any of these like Byram's?—Mr. Pasquet's and Mr. Lessoine's are similar in construction to Byram's.

138. Those are on the principle of the windmill?—Yes; and Mr. Nasmith's fan resembles Mr. Letoret's, with the exception of the angle in the vanes, and it is apparently not so good as the original.

139. *Chairman*.] Which of these ventilators is considered the best in Belgium?—Mr. Fabrey's.

140. Is that most commonly used?—Yes.

141. Do you agree that Mr. Fabrey's is the best?—Yes; I think Mr. Fabrey's is the best. None of these ventilators appear to be adequate to give what would be considered a large amount of ventilation in this country. The average amount of ventilation they are giving, is about 20,000 cubic feet of air per minute; and in few, if any, cases do they reach 40,000. I have a list of experiments which have been made in certain mines.

[*The Witness delivered in the List, which is as follows:*]

BELGIUM.—COAL MINES.

EXPERIMENTS with VENTILATING MACHINES. (The Volumes of Air were measured by Powder Smoke.)

NAME of the VENTILATOR.	NAME of the COLLIERY where the Experiment was made.		REVOLUTIONS per Minute.		Water Gauge, in Inches.	Cubic Feet of Air extracted per Minute.	DIMENSIONS of VENTILATOR.	
			Strokes of Steam Engine.	Revolutions of Ventilator.			Diameter across the Fans, in Feet and Inches.	Breadth, in Feet and Inches.
							Ft. In.	*Ft. In.*
Mr. Fabrey's - 1	- - Grand Puisson at Hornu - - -	Maximum -	- -	30	2·16	21,213	—	—
		Minimum -	- -	23	1·02	11,655	—	—
Ditto - 2	- - Bonne Esperance at Montegnies - -	Maximum -	44	- -	2·36	20,157	—	—
		Minimum -	30	- -	1·10	17,271	—	—
Ditto - 3	Gouffre - - -	Maximum -	39	31	1·65	17,165	—	—
Mr. Letoret's - 4	- - Capatout, No. 8, Belle Vue - -	Maximum -	70	210	1·77	27,125	9 10	4 11
		Minimum -	30	90	0·39	10,656		
Ditto - 5	- - Grande Veine d'Elouges - -	Maximum -	60	240	2·16	19,441	9 2	3 10
		Minimum -	30	120	0·90	10,939		
Ditto - 6	- - Escouffiau, No. 1, at Hornu - -	Maximum -	75	337½	1·77	16,741	6 6	3 3
Ditto - 7	Long-terne - -	Maximum -	87¾	325	1·81	10,939	8 2	3 3
		Minimum -	45	168¾	1·37	8,476		
Ditto - 8	Agrappe, No. 2 -	Maximum -	70	200	1·37	38,145	9 10	4 11
Ditto - 9	St. Antoine, Nord -	Maximum -	65	217	2·36	23,946	9 10	4 11
		Ordinary -	43	143	1·18	20,026		
Ditto - 10	Vidette, Nord - -	Maximum -	38	152	1·53	16,618	9 10	4 11
Ditto - 11	Sentinelle, Nord -	Maximum -	41	164	1·47	21,685	9 10	4 11
Mr. Fabrey's - 12	Enbas - - -	Maximum -	21	21	1·47	23,692	6 6	9 10

No. 9.—The pits are 209 yards deep. Two seams are being worked. The air is in three splits, 1,200 yards each; airway, 28 feet area; downcast pit, 26 feet area; upcast pit, 58 feet area.

No. 10.—Pits 298 yards deep. One current, 2,500 yards long. Downcast, 58 feet area; upcast, 53 square feet; area of airway, 26 feet.

No. 11.—Pits 360 yards deep. One current, 1,330 yards long. Downcast, 55 feet area; upcast, 44 feet.

No. 12.—Pits 283 yards deep. Five currents; 1st, 1,100 yards; 2d, 450 yards; 3d, 450 yards; 4th, 1,200 yards; 5th, 1,200 yards. Two downcasts, 95 feet area; one upcast, 74 feet area.

Taking the maximum results of the experiments with Nos. 9, 10, 11 and 12 ventilators, which were worked by steam-engines of 12, 15, 15 and 18 horses power, the quantity of air obtained by each machine was at the rate of 21,485 cubic feet per minute; and allowing 12 lbs. of coals per horse-power per hour, 7,162 cubic feet of air was obtained per lb. of coals consumed in the boiler fires.

COST of Nos. 9, 10, 11 and 12 VENTILATORS, together with the STEAM ENGINES and ERECTIONS.

No.	Horse Power of Steam Engine.	ENGINE and VENTILATOR.	BOILERS.	ACCESSORIES.	BUILDINGS.	TOTAL COST.
		£. s. d.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
9	12	152 — —	146 — —	16 — —	188 — —	502 — —
10	15	190 — —	147 — —	- - -	168 — —	505 — —
11	15	190 — —	148 — —	- - -	155 — —	493 — —
12	18	364 — —	147 — —	- - -	180 — —	691 — —

142. Do you think either of them is as good as Mr. Struve's, as a mechanical apparatus?—Perhaps, if there is a line to be drawn, I should be disposed to think Mr. Struve's plan preferable to any of them.

143. Do you mean with reference to cost?—With reference to economical working.

144. What is the depth of the shaft in the Belgian mines?—Many of them are very deep; they are upwards of 500 yards deep.

145. Mr. *Locke.*] To what extent do they work from the shaft?—In many cases nearly a mile. As a general rule, they are much shorter, with a number of levels at work in different seams.

146. Is that the description of mine where they only supply 20,000 cubic feet?—That is the whole amount of the ventilation for the whole working of a mine of that kind.

147. Can you state the number of men who are generally employed in a mine of that description in Belgium?—About 250.

148. *Chairman.*] Do you consider that this mechanical system of ventilation is a satisfactory system, and is it such a system as you would recommend to be adopted in this country?—No; I am not an advocate of it.

149. Will you state your reasons for that opinion?—It is not generally so steady in its action as the furnace; with a furnace at work you are not liable to very sudden interruption, which is a very important objection.

150. Can you furnish some information to the Committee as to the cost of putting up these machines; does it vary from 500 *l.* to 700 *l.*?—Yes.

151. Is there a large quantity of fire-damp in Belgian coal mines?—As a general rule, there is not a large quantity of fire-damp in any of the Continental mines. There is most at Liege; and it appears to decrease westward, until in the same basin, at Valenciennes, in France, in mines 500 yards deep there is scarcely any.

152. Should you rank the most fiery mines of Belgium with the moderately fiery ones of this country?—I should rank the most fiery mines of the Continent with the moderately fiery mines of this country, from personal observation, and from all I could learn with reference to the amount of fire-damp.

153. You would not compare them with the fiery mines of the North of England?—They do not appear to yield as much fire-damp.

154. Is the furnace used at all in Belgium?—Yes, to some extent.

155. Is the system of steam jet used in Belgium?—No; there is an opinion that steam jet is not a sufficient ventilating power.

156. Do they admit the furnace in mines where fire-damp is found?—No; it is inadmissible in mines which are called fire-damp mines.

157. When you say "inadmissible," do you mean that the inspectors do not allow it?—It is inadmissible by law, unless fed by a scale of fresh air; and the amount of fresh air which is supplied to the furnace in Belgium is generally very small, and the temperature of the up-cast shaft is disproportionately low, and the amount of air passing through the working is small accordingly.

158. You mean to say that there is not enough air passing over the furnace to create a brisk circulation of air, and make the furnace burn sufficiently strong?—There is not. I think that if they gave the furnace a larger amount o fresh air, they would increase the combustion of coal; they would raise the temperature of the up-cast, and materially increase the quantity of air circulating through the workings.

159. Do they build high chimnies in Belgium?—They do.

160. Where do they put them?—They build them at the top of the up-cast shaft, for the purpose of assisting the furnace, or for the purpose of carrying on the mine by natural ventilation. Some of those chimnies near Liege are 220 feet high by 9 feet diameter, diameter inside.

161. Mr. *H. Vivian.*] Have you taken the temperature of any of the up-cast shafts in Belgium?—We did not; but in going down them it is very easy to ascertain whether it is a high temperature or a low temperature.

162. Did you go down without the slightest inconvenience?—Yes.

163. Are they devoted entirely to the up-cast, or do they draw through them?—They sometimes draw through them.

164. Generally?—Generally speaking, they have a separate shaft for the up-cast.

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165. Are they bricked shafts?—No; the Belgian pits are even worse secured than our own.

166. You are aware that the efficiency of a furnace depends a good deal upon the state of the shaft?—Yes.

167. If a shaft is not bricked you cannot raise the temperature so much as you can if the shaft is bricked; and consequently, you may state, as a general rule, that a furnace not working into a bricked shaft is not in a condition to produce the best effect?—There is no doubt that an up-cast shaft is better for being bricked up from top to bottom; I think that all shafts should be bricked up from top to bottom. It is not common, either in Belgium or in France, or Prussia. In all the collieries that we visited, we only met with one colliery (and that was a very large one, and managed in a superior manner) where the shafts were bricked throughout.

168. *Chairman.*] Where was that?—At Mariemont.

169. Do you confine that observation to the up-cast shaft?—It applies to all the pits.

170. Mr. *H. Vivian.*] Then it may be assumed that the furnace, as applied in Belgium, is not well applied?—It is not applied in the efficient manner in which it is applied in this country.

171. What is the highest amount of ventilation that you have seen obtained by the furnace in Belgium?—I have stated that it is very small. I do not know that we saw any case where the furnace ventilation exceeded 20,000 cubic feet per minute.

172. And the diameter of the shaft?—Some of the old up-cast shafts are very small in Belgium. I have stated the size of several of the shafts in the table which I have put in.

173. Then, as a whole, the system of ventilation by furnace is very imperfectly carried out in Belgium; the shafts not being bricked, and being small in diameter?—Yes, and owing to the other causes which I have stated.

174. Mr. *Cayley.*] Can you account for their having applied themselves to mechanical power, rather than to the furnace?—The principal object is to avoid explosions at the furnace.

175. Did they pursue the furnace system before they applied the mechanical system?—I do not know whether they did or not; but an immense quantity of ventilation, on the Continent, is carried on by natural ventilation.

176. Mr. *Fitzroy.*] What do you call "natural ventilation?"—Where no ventilating power is applied.

177. Mr. *Cayley.*] Did you make any inquiry as to the extent to which the furnace system had been tried in Belgium?—Yes; we made a general inquiry as to the mode of carrying on the mines, both by mechanical means and by furnace.

178. Have you any well-ascertained experiments as to the comparison between the furnace system and Mr. Fabrey's fan?—There is no case where the furnace is at work at the same time as Mr. Fabrey's ventilator.

179. Have they ever tried one first and the other afterwards?—There are cases where these mechanical appliances are at work occasionally, and where the top of the shaft is thrown open, and the mine carried on by natural ventilation, the mechanical appliances being stopped.

180. Has the furnace been tried first, and then the mechanical system; and can you state which produced the greatest amount of ventilation?—If any experiments of the kind have been made, I have not obtained them.

181. Is it at the Government instigation that these mechanical means are used?—I am not aware that there is any law to compel them to resort to any particular system of ventilation; but, in the police of mines, it is necessary to have some current of air in all parts of the working, and that every part of the working shall be well ventilated, and not in an explosive state; if any part of the mine becomes explosive, or if gas is apparent on the flame of the lamp, the workmen must retire.

182. Does the police act under the inspectors?—Yes; the inspectors carry out the Police Act, which is a part of the code of mining laws.

183. Are there any instruments in the mine to test whether there is a sufficient amount of ventilation going on?—Nothing of the kind; indeed instruments seem to be very little used in any of the continental mines; we saw two of Mr. Combe's anemometers.

184. Do they insist on any particular rate of current going on through the mine?—No; there is no such regulation.

185. What test of safety do they apply?—The only test of safety is, as I have described, that the mine must be well ventilated in all its parts; it must not be explosive; and if the flame indicates the presence of gas without being explosive, the workmen must retire. In cases of very great danger, I think they are bound to report it to the inspectors.

186. Mr. *Fitzroy.*] Is the proprietor of the mine responsible for the safety of his men?—Certainly.

187. Are there any regulations laid down by the Government inspectors for the purpose of introducing any particular system?—No; I am not aware of any law.

188. Mr. *Locke.*] Nor any stipulation for the use of the furnace, or fan, or jet, or anything else?—No.

189. Is the actual state of the mine the index by which the inspector would judge of the necessity for any change of system?—It is.

190. Mr. *Fitzroy.*] Are there no regulations whatever laid down by the Government inspectors?—There are certain regulations; for instance, one is with regard to the furnace. If admitted into a mine which gives off fire-damp, it must be fed with fresh air exclusively.

191. Mr. *Locke.*] Is that so?—In all the furnaces that I saw it was so.

192. Mr. *Fitzroy.*] Is there any penalty for the infraction of the regulations?—A book is kept at each mine, in which an inspector on visiting the mine, and finding danger, writes it down, and directs attention to the danger; and in the event of his recommendation not being carried out a punishment is awarded, according to a scale which is laid down.

193. Is the control which is exercised by the Government inspectors in Belgium, more stringent than that which is exercised by the Government inspectors in this country?—Much more.

194. Are their powers more extensive?—They are.

195. In what way?—They can enforce the use of the safety-lamp in the Belgian mines, which we cannot do here. There are only four lamps which were approved of by the Belgian Government. Any current of air which may have become mixed with fire-damp must continue to ascend until it reaches the out-cast shaft. It is an essential principle of ventilation, in Belgium, and no departure from it can be allowed, unless it is formally sanctioned by the inspectors; a consent which is seldom given. Restrictions of that kind are in force in the Belgian mines.

196. Have the Government inspectors power to stop the working of any ill-ventilated or dangerous mine?—When they find any danger, as I have said, they make a note of it in a book, which is kept for that purpose at the colliery; and in the event of their notice of its being disregarded, and an accident ensuing, and life being lost, a degree of punishment is awarded for that neglect. When the danger is imminent they can order the men out.

197. Can they stop the working of the mine?—Yes.

198. Under what penalties are these regulations enforced?—There is a scale of penalties, but I am not prepared to state them.

199. Pecuniary?—Both pecuniary and otherwise.

200. Do the proprietors become liable, in any case, for the maintenance of the families of workmen who are injured in the mines?—I am not aware of it.

201. Mr. *Cayley.*] In Belgium, are they very strict as to the size of the air courses?—The size of the air courses is not defined. The only regulation with regard to the air courses is, that the gobbing must be packed as tightly as possible, and the air-ways must be accessible in all parts, and must be travelled at certain intervals of time, which are specified.

202. Then there are no other means of testing the safety or danger of the mine, except the length of the flame in a safety-lamp?—That is the plan adopted.

203. Have you ever heard of Chuard's gasescope?—I have heard of it.

204. Are you aware whether it is of value?—I am not.

205. Mr. *H. Vivian.*] Is the lamp a very accurate test?—Yes.

206. Mr. *Cayley.*] Are the lamps first used by the overmen at the commencement of each day, or at particular periods of the day, to test by the lamp the

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state of the air in the mine?—There is a fireman, as in this country, who must examine every working place before the men enter in the morning; in fire-damp mines only safety-lamps are admitted.

207. That is compulsory?—Yes; and if powder is permitted to be used in a fire-damp mine, the shots must be fired by an experienced person, appointed for that purpose; the men who fire the shots are like the firemen in this country; on no account must the mine be left without one of these firemen or overmen being in the mine during the time the men are at work; it is also a part of their duty to report breaches of discipline to the manager of the colliery.

208. Mr. *Child.*] In point of fact, there is a Government inspector?—He belongs to the colliery.

209. *Chairman.*] The inspector has two duties, one with reference to the safety of the mine, and another as collector of the tax for the Government; is that so?—Yes.

210. Mr. *Cayley.*] How often do the inspectors visit the mine?—It depends very much upon circumstances; some mines they visit oftener than others.

211. *Chairman.*] You have been asked whether any experiments had been tried as to the furnace, and what was the reason of the failure of the furnace, and you were understood to state that the furnaces were improperly worked, inasmuch as there was not sufficient atmospheric air passed over the furnace; is that so?—Yes.

212. If any experiments had been tried with furnaces and mechanical ventilation, those improvements would have been in vain, because the power of the furnace would not be brought out?—Exactly so.

213. Do you conceive there would be any danger in carrying more fresh air over the furnace, provided the same quantity of foul air were brought over the furnace with it?—In this country we generally consider it safe to work the return air over the furnace; and the furnace works most economically when all the return air is worked over it.

214. Mr. *H. Vivian.*] In many instances, where the returns are very much loaded, you have a dumb drift?—In mines where there is any chance of the return air being highly loaded with gas, or where the mine is liable to sudden eruptions of gas, the proper way is to have the dumb drift; but it is only in exceptional cases where dumb drifts are to be met with.

215. In that case, is all danger from the furnace avoided?—It is.

216. Mr. *Child.*] What is the longest level you saw in Belgium?—A mile from the shaft.

217. Was that an explosive mine?—I think there was a little fire-damp in it.

218. Was it adequately ventilated by means of mechanical power?—It would be considered adequately ventilated in Belgium; but in this country we should give it a much larger supply of air.

219. Mr. *Cayley.*] You have stated that, in Belgium, the steam jet has not been favourably received?—It has not been approved of.

220. Has that arisen from trial or from prejudice?—Experiments have been made with it, and it has been condemned for some time in Belgium.

221. Have you reason to believe that it was properly tried, or that it was tried by those who understood it?—I should think that, with such a number of scientific men as the Belgian mining engineers, it is scarcely to be supposed that they would come to a unanimous opinion upon the point without a fair trial.

222. Do you know of any particular instance in which it was tried, and under what auspices?—There were some experiments tried; and I think Mr. Mackworth will put them in.

223. Notwithstanding the scientific attainments of the mining engineers in Belgium, you have stated that they have not tried the furnace system properly?—In my opinion the furnace is not carried out so well as it is carried out in this country.

224. *Chairman.*] With regard to inspection: will you describe the system of inspection, and the number of inspectors, in Belgium?—In Belgium there is one inspector-general at Brussels, three engineers-in chief (only two of whom are at present on duty), 10 sub-inspectors, and 40 aspirant engineers; this is for the coal and other mines, and for the manufactories of raw materials; there being other inspectors for the railways. The engineers and sub-engineers are selected as experienced men; the aspirants are scientific men, and must be

be 23 years of age, and must have previously studied two years at a preparatory school, and three years at college, with occasional visits to the mines; the sub-engineers are sometimes elected from the aspirants, but not always.

225. Mr. *Fitzroy.*] How many sub-engineers are there?—There are 10 sub-engineers; I called them sub-inspectors, which is the same thing.

226. Mr. *Cayley.*] There are 54 of them altogether?—Yes.

227. *Chairman.*] Are the 40 aspirants paid?—Yes.

228. Mr. *Fitzroy.*] Is it their duty to inspect mines, and to report upon them?—The duty of the aspirant engineers is to inspect the mines, and to report to the officers above them.

229. In point of fact, to carry out the police of the mine?—Yes.

230. *Chairman.*] The aspirant engineers do not always become sub-inspectors, but very often become managers of mines, and take any other employment they think fit?—That is so.

231. Mr. *Fitzroy.*] What are the duties of the three engineers-in-chief?—They visit mines occasionally, and see to the working of the corps over which they preside. The aspirant engineers' duty is to be constantly visiting mines; the sub-engineers, above them, visit mines when their attention is directed to any danger which the aspirant engineers think is capable of being removed; and if anything particular takes place, one of the engineers-in-chief is called in. They have also to make up the statistics of the number of accidents which take place in the districts; and they have also to check and verify the plans of the colliery, and to look after the per-centage which is payable to the government; a duty which is performed in this country by the check-viewers, who are employed and paid by the lessors.

232. Are the Committee to understand, that in point of fact the inspection of the mines is performed chiefly by the aspirants, and that the sub-inspectors only visit the mines when representations are made of some danger being likely to happen?—I think they direct their attention, first, to a point which has been drawn to their attention; but I believe it is a part of their duty to visit the mines also.

233. What other duties do the sub-inspectors perform, besides that of inspecting any particular mine to which their attention is drawn by the aspirants?—They perform the very important duty of looking after the per-centage on the profits of the colliery, which is payable to the Government. In Belgium, 2½ per cent. of the profits is payable to the Government.

234. *Chairman.*] In every case?—Yes.

235. Mr. *Fitzroy*] Then in the event of any danger being likely to arise in a mine, is it necessary that the aspirant should report to the sub-inspector, and the sub-inspector to the superior authority, before any steps are taken to check the danger?—An aspirant engineer can only act according to the instructions which he has received from the administration.

236. He can only report?—In case of any great danger, I believe he has the power of stopping the mine.

237. Then, in point of fact, he is the judge of the danger, and of the necessity of taking immediate steps?—Yes.

238. In point of fact, the aspirant fulfils all the duties which now devolve upon a mine inspector in England?—With this difference, that he has superior officers who have had experience in the mines to consult, and we have no superior officer, except the Secretary of State; we must act on our own judgment in such matters in all cases.

239. Is the duty of the aspirant only to represent danger, or to take measures to avert danger?—Partly to avert danger, and also to look after the interest of the Government, which is tantamount to a lessor of coal in this country. It is the duty of all the corps to look after the interest of the Government.

240. Can the aspirant act independently to preserve the safety of the mines?—I think he can; but no doubt, in a critical case, he would immediately consult his superior; he might, in a case of urgent danger, stop the mine; but such a thing very rarely happens, and it is almost unknown for a mine to be stopped.

241. You have stated, in a former part of your evidence, that mines are stopped in cases of danger; upon whom would that duty fall?—In the first place, upon the aspirant engineer; no doubt he would consult his superior officer; and the superior officer would visit the mine as early as possible.

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242. *Chairman.*] Have the inspectors in England that power?—We have no such power.

243. Mr. *Locke.*] Will you turn to the rules of the police in Belgium, and state what is the power which the aspirants have of stopping the mine?—Mr. Mackworth and myself have arranged the evidence between us, and we have an interpretation of the police rules, which Mr. Mackworth will give in his evidence.

244. *Chairman.*] You say that the Government receives 2½ per cent. of the profits. Of course the profits would depend very much upon the success of the undertaking, and the success of the undertaking would depend very much upon whether the mine was worked properly or improperly. Is it the duty of any of these officers to see that the mine is worked in a proper way, so that the Government are not damnified by improper working?—It is an important part of their duty, in addition to looking after the safety and health of the workmen, to look after the interest of the Government.

245. If, therefore, a mine was worked in such a way that the Government received less profit than they ought to receive, and had the opportunity of stopping the mine and getting it worked in a proper manner, is that a part of their duty?—I do not know that it is put forward as a part of their duty, but practically they have an interest in seeing the mine properly worked.

246. Mr. *Fitzroy.*] What is the duty of the three engineers-in-chief?—They go down the mines occasionally; some of the engineers take the charge of iron-works and other manufactories as well as of coal mines; one of the engineers at Liege, Mr. Gernaert, looks after the interest of the Government in the management of the Seraing Iron-works.

247. Mr. *Locke.*] Do you know of an instance in which the extreme step of stopping a mine has been taken, without special reference having been made to the engineer-in-chief?—I do not know of any case where a mine has been stopped; if such cases have occurred they are very rare.

248. Do you think, from your knowledge of the management of the mining system in Belgium, that if such a course were decided upon it would be decided on without the consent of the engineer-in-chief?—I think that before an aspirant engineer, who is generally young and although of great scientific attainments, they are not always experienced colliers; before they would take such a step as to stop the working of a mine, I think he would point out the danger, and request that the working of the mine should be stopped until the opinion of his superior officer had been taken; and, upon the superior officer visiting the mine, if he considered, with the aspirant engineer, that the danger was imminent, and the proprietor of the mine thought that it was not imminent, steps might then be taken, but not until the superior officer had been called in.

249. Mr. *Fitzroy.*] Has an aspirant engineer the power of stopping a mine?—I believe he has that power.

250. Of that you are certain?—The duties of all the corps are laid down in the code of mining laws, and as my time for visiting the mines was limited, I devoted myself more to the practical part of the subject than to the laws which may be read at any time.

251. Mr. *Cayley.*] With what particular object were you sent to Belgium?—The principal object was to ascertain the best system of ventilating mines. there has been so much difference of opinion on the subject, and since the appearance of the Report of the last Committee on coal mines there has been such a ferment created among the colliery managers, that our object was to ascertain the opinion of Belgian engineers; also to ascertain, by actual inspection, whether they had any better system of ventilation than we have in this country, and if so, to introduce it for the purpose of improving the management of mines here; and also to ascertain generally, whether on any other points the mines were better managed than they are in this country, so that improvements might be introduced here.

252. Was not one of the principal objects with which you were sent, to examine into the system of inspection of mines in Belgium and other countries?—It was no part of my instructions to inquire into the inspection.

253. Mr. *Fitzroy.*] Your instructions referred to the general management of the mines?—Yes; the subject of inspection having been reported on by Mr. Tremenheere, who has given the general outlines of the system which is adopted, it was only important to inquire into it so far as it bore upon the practical operations of the mines.

254. Of course the inspection of mines would form a very material part of the management of mines?—No doubt.

255. *Chairman.*] Both going together, and having a great deal to do in a short time, it was natural that you should have applied yourself to one branch of the subject, and that Mr. Mackworth should have applied himself to another?—My attention was chiefly directed to the system which was adopted of working and ventilating the mines, and to any management which tended to preserve life.

256. Mr. *Cayley.*] Is it to be understood, that in that division of labour Mr. Mackworth attended more to the Government system of inspection, and that you examined more into the system of ventilation?—No.

257. With regard to the size of the districts; how large is the district of each aspirant engineer?—I may answer that question by adverting to the quantity of coal which is raised, or to the number of persons who are employed

258. How often do the aspirant engineers visit the mines?—In the best managed collieries, where every precaution is taken by the managers, I believe they do not visit them more than once a year, or more than once in two years, or merely for the purpose of verifying the plans when a working is being finished; but mines which are considered unusually dangerous are visited very frequently, I believe sometimes once a month.

259. Do the 40 aspirant engineers indiscriminately visit the mines, or is one district assigned to one aspirant engineer, or to a given number of aspirant engineers?—A certain district is assigned.

260. What is the size of that district?—I can give the quantity of coal raised in the whole of Belgium; and you have the number of engineers.

261. How many mines does he superintend?—I cannot state the exact number; there is no given number.

262. Is the number of mines in Belgium very large?—No; it is about one-eighth part of the number we have in this country.

263. You state that in very fiery mines, the visits of the inspectors are on an average monthly?—Not in the very fiery mines, but in the badly managed mines. In mines which are well managed, even although there be a large quantity of fire-damp, the inspectors' visits are few and far between; but in mines which are badly managed, their visits are much more frequent.

264. Are the visits of the inspectors in Belgium more frequent than they are in this country?—Of course.

265. For what reason?—There are only six inspectors for this country; and if we have eight times the number of collieries apportioned among six, of course the visits must be very much fewer here.

266. How long would it take you to visit the whole of your district?—Several years.

267. How many years?—I do not think that I could visit each colliery under four or five years.

268. You could not go through your district under four or five years?—I do not think I could.

269. What salaries do the engineers receive in Belgium?—I cannot answer the question.

270. Can you compare the sub-engineers to any class in this country?—They are men of good education, and are supposed to have had experience in mines, and to understand the working of mines practically.

271. Where do the aspirant engineers reside?—In the districts which they overlook.

272. Where do the sub-engineers reside?—They reside also in the districts which are assigned to them.

273. Where do the three engineers-in-chief reside?—They reside also in the districts which are assigned to them.

274. Then they are not a council of three, but they are three engineers-in-chief, occupying three different districts?—Yes.

275. What is the office of the inspector-general?—He is a person who takes charge of the general working of the corps.

276. He is a sort of Government Commissioner of Mines residing in the metropolis?—Yes; and who rarely, if ever, goes into the mines; but who is, I believe, always an experienced man.

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277. In what case is reference made to him?—I think reference is very rarely made to him; but either in an extremely critical case, or perhaps on the occasion of anything novel being introduced into the mine, he might go for the purpose of seeing it.

278. Is he the medium of communication with the Government?—Yes.

279. *Chairman.*] Is there a book kept at each mine for the engineers to write remarks in?—Yes

280. If there is danger, do they so remark?—If there is any danger which they think can be removed, they make a note of it in the book; and if steps are not taken to remove the danger, and an accident happens, the colliery proprietors are made responsible, and they are fined or punished accordingly.

281. Who levies the fine?—It is done through the magistrates.

282. Upon the information of the sub-inspectors, or of the engineers-in-chief?—It depends on which of the inspectors have seen the danger.

283. Suppose it is an aspirant engineer?—He would give the evidence.

284. He would go before the magistrate and give information, and the fine would be levied if his orders were not obeyed, and an accident took place?—Yes.

285. Mr. *Fitzroy.*] Are you aware of a class of workmen who are charged with the inspection of a mine, and have power to stop a mine in case of danger, and whose duty it is to ascertain that a mine is safe before the workmen go in?—They are a class of men who are employed by the proprietors of the mines; they are similar to our overmen and firemen in this country; they are not paid by the Government.

286. The number of them is fixed by the inspector of mines according to the extent of the works, the nature and abundance of the gases, and the degree of security which the system of ventilation provides?—Yes.

287. Are they Government officers or not?—No.

288. Are they appointed by Government officers?—No.

289. Mr. *Cayley.*] Do they undergo any examination?—Yes, the Government engineers have all to pass examinations; if an aspirant engineer, on being appointed an aspirant engineer, passes a very excellent examination, he may be at once admitted a sub-engineer, without going through the degree of aspirant engineer.

290. Do the aspirant engineers, or whoever has the control over the overmen, insist with the proprietors of mines, that the overmen, on whom the safety of the mine depends, shall pass an examination, or have any particular qualification for their office?—I do not know that they do.

291. *Chairman.*] The aspirants themselves must be of a certain age?—Yes.

292. Mr. *Cayley.*] The object of my question is to ascertain whether the Government so far interferes, that although it does not absolutely appoint the overmen to watch over the safety of the men, yet it exacts that they shall be of any particular class, or possess some particular qualifications?—They must be experienced men, and competent to carry on the work; I do not know of any examination, and I believe there is none.

293. *Chairman.*] Are naked candles ever used in the mines in Belgium?—Yes; in mines which do not contain fire-damp; but in fire-damp mines lamps are used exclusively.

294. How are they used in the waggon roads?—In many of the mines the waggon roads are lighted by lamps hung from the roof, as we sometimes find in this country.

295. Mr. *Locke.*] What kind of lamps?—Safety-lamps.

296. *Chairman.*] Near the up-cast pit do they use naked candles?—No; they are very careful to have no naked candles on the surface near the mouth of the up-cast pit, and safety-lamps hung up in the engine-house, where a ventilator is at work.

297. Are there any descriptions of safety-lamps which are exclusively used?—There are only four lamps which are approved of by the Government; namely, Davy's, Museleer's, Boty's, and Eloin's.

298. All those which are used are glass, except Davy's?—Yes.

299. Which is most commonly used?—The Museleer lamp is the lamp which is commonly used. Very great confidence is placed in it in Belgium.

300. Do the glasses often break in those lamps?—It depends on circumstances. The proportion, as stated to us at some of the large collieries, where there

there were between 300 and 400 lamps in use, was at the rate of one glass per week for every 200 lamps in use.

301. Mr. *H. Vivian.*] Would that be cracks of the glasses, or fractures?—That is the proportion of new glasses required.

302. From a simple crack no danger could occur, and from an actual fracture of a lamp danger might occur?—It is better not to use cracked glasses, as flame passes through a smaller hole in glass than in iron; all the lamps which are approved of, except Davy's, are self-extinguishing lamps, in Belgium; so that there is not a continual flame kept up in the inside of the lamp, which might break the glass.

303. *Chairman.*] Can you state the difference in the cost of these lamps?—Each mine generally makes its own lamps in Belgium.

304. The whole of the lamps?—Yes; they are generally very rough as compared with our lamps. This Davy lamp (*pointing to a lamp on the table*) would not be considered a good lamp here; it has no cap to it; it has no ring at the bottom to prevent the gauze from bulging out; it is sold at 3*s.* 4*d.* The Museleer lamp is sold at 5*s.*, and if it is made with copper wire, for dialling with, it is sold at 7*s.* 6*d.* The Eloin lamp is sold at 8*s.* 4*d.* if it is made of brass, and 5*s.* if it is made of iron.

305. What is the price of an ordinarily constructed Davy lamp in England?—About 5*s.* 6*d.* for a good lamp.

306. Is there any difference in the weight of them?—The Museleer is the heaviest.

307. Is there any difference in the quantity of light?—The Eloin lamp gives the best light; the supply of air all comes from the bottom, and it is thrown upon the flame by an argand burner.

308. Which do the men prefer?—The Museleer is generally preferred. The Eloin lamp is a new lamp, and we did not see it in use in any mine in Belgium; it was only recently introduced.

309. Mr. *H. Vivian.*] Is the expense an objection?—No; that does not appear to be made an objection. The Museleer lamp is about the same price, and it is in common use.

310. *Chairman.*] Do the proprietors of the mines provide the lamps?—Yes.

311. Mr. *Cayley.*] Are they compelled to keep them locked?—Yes; the lamps are always locked; and they must not be opened in the mine, unless at the bottom of the downcast pit, where there is a place set apart for the purpose.

312. Is it not the habit of the workmen in this country to unscrew the top of the lamp and work with the flame?—Sometimes; but they can be punished for doing so.

313. In this country?—Yes. The magistrates do not appear to be unanimous in their opinion upon that point, for in some cases they convict and in others they do not. At Wigan there is no difficulty in convicting the miners; they proceed under the 4th of George the 4th, chapter 34, section 3.

314. What is the method pursued in Belgium, to prevent that habit which exists among the colliers in this country, of unscrewing the tops of their lamps and burning the naked flame?—I know of no other precaution except locking the lamps, and they are very strict in punishing. In fact, discipline is kept up in the Belgium mines rather better than in our mines; the men are in excellent discipline, and for a man to open a lamp, I think, is a thing hardly ever heard of.

315. Do you attribute that better discipline to a better system of inspection?—I think it pervades the miners generally.

316. Are the men better educated?—As a general rule, I think they are.

317. Are the overmen better educated?—No; I do not think they are a better class of men than ours.

318. *Chairman.*] Do you think the men themselves are more sensible of the danger of unscrewing their lamps in Belgium than they are in England?—I think they are; some of our men in certain parts of England are very careful, and would not on any account think of opening their lamps. Other men are very reckless; and unless they are well looked after they will do it.

319. Mr. *Fitzroy.*] What is the penalty in Belgium for opening a lamp?—It is a thing which is almost unknown. An order is given that the lamps shall not be opened, and the order which is given is carried out. They would be taken before a magistrate, and punished for an infringement of the order.

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320. You do not know of any penalty?—I do not know of any specific penalty.

321. Mr. *H. Vivian.*] What penalty has been inflicted at Wigan?—Three months' imprisonment.

322. Mr. *Cayley.*] What is the object of the miners in this country in taking off the top of the lamp?—With a view of getting a better light, and sometimes for the purpose of trimming the wick, and sometimes without any apparent motive.

323. Does the gauze obstruct the light very much?—Yes.

324. Is it a fact that they generally work with the lamps behind them?—Partly behind them, and partly at their side.

325. When they are working with the lamps behind them, they do not see the flame lengthening, so as to indicate the presence of foul air?—No.

326. Do you consider that the meshes are sufficient to prevent the flame coming through?—The large size of the mesh appears to be a weak point in Eloin's lamp; but being at the top of the chimney, nothing but consumed air passes through it. I have never myself been able to pass gas through the gauze.

327. Is the Eloin lamp a lighter lamp for a miner than the Davy lamp?—No; it is rather heavier than the Davy.

328. Does it give more light?—Yes; there is an argand burner applied to the Eloin lamp, which draws the air on the flame, and creates a very perfect combustion.

329. Would it not add much to the light which is given out from the Davy lamp if it were made of polished wire gauze, instead of black iron wire?—The lamps are made of wire, which, on being brushed with a little Bath brick, or ashes, become perfectly bright. Since the recommendation of the last Committee, I have ordered what are called reflecting lamps, and this is one of them (*pointing to a lamp on the table*). The wire gauze is coated with tin, and immediately on becoming exposed to an explosive atmosphere the tin melts and runs down in globules. It becomes much discoloured, and the meshes of the gauze get filled up with the globules of tin. It is by no means so good as the ordinary wire.

330. *Chairman.*] Supposing it be an advantage to have the wires polished and perfectly bright, how long will they keep clean after being down the mine?—They must be brushed every night.

331. Would they keep clean a whole day?—In a dry mine, if you tap the lamp the dust falls off.

332. There is no great quantity of smoke?—If the flame is too large the smoke will blacken it; but if the flame is kept small, you may avoid the soot.

333. Mr. *Cayley.*] Does not the safety and sufficiency of the lamp depend altogether upon its being kept clean?—Yes.

334. What system is pursued in Belgium to ensure the cleaning of the lamps?—They are cleaned every night. There is a lamp-house at the door of the pit, where the lamps are left as the men go out, the same as we have in many of our best managed mines in this country. The lamps are cleaned, and are given to the men as they go to work in the morning.

335. Mr. *Fitzroy.*] How many hours will a common Davy lamp burn?—It is always made to burn 12 hours, so that a man may not have an excuse for leaving his work.

336. Mr. *Cayley.*] Will you describe the objection which you have stated with regard to the melting of the reflector?—The coating of tin which is put on the wire gauze melts.

337. Was not the proposition that they should be electro-plated with silver?—I ordered those lamps of one of the first makers in the country, Mr. Watson, of Newcastle-on-Tyne; and upon making an experiment with them, I found that instead of possessing any advantage, as polished wire-gauze lamps, they possessed the very great disadvantage which we are cautioned against by Sir Humfrey Davy himself.

338. Would they have melted if they had been silver plated instead of tin plated?—I should think silver would melt. It would not melt at so low a temperature as tin. If you pay proper attention to the wire gauze, and brush it every night with a little Bath brick, or fine ashes, or a little chalk, or anything, it will throw a polish on the wires and make them as bright as silver; and in some cases, where the gauze is properly brushed, you have it as bright as silver.

339. *Chairman.*]

339. *Chairman.*] You stated that you had not paid any attention to the recommendation of the Committee as to coating them with silver; and, therefore, you cannot state what the expense would be if they were coated with silver?—I cannot; I ordered the polished wire gauze.

340. Mr. *Cayley.*] If there is a constant habit, among miners in this country, in order to obtain a better light, to unscrew the tops of their lamps, is it not a matter of very great importance to have a lamp of some kind which will give them that better light, without unscrewing the top?—Yes; it is very desirable.

341. Is it a fact, that in visiting the mines in your district, you found the lamps in the polished state which you have described?—In some cases; but I think, in the majority of cases, they are not properly brushed.

342. In point of fact, do the lamps now tend to absorb the light?—A great proportion.

343. If the silver-plated lamp would have the effect of reflecting a greater light, it would not be liable to melt at the heat which is in the lamp; would not that be a desideratum?—I think the same object would be attained by polishing the gauze; it is necessary, I consider, to have the lamp clean to ensure safety, and in cleaning the lamp you polish it, so that you attain the same object at a cheaper rate.

344. In point of fact, practically, the lamp is not in that state of polish on the average?—That is, where the lamps are not clean.

345. You stated that practically lamps were not in that polished state in which you think they should be in order to gain that greater light which you consider a great desideratum?—Yes.

346. You are aware that silver does not melt except at white heat?—I do not recollect the temperature at which it melts; but I am aware it is considerably higher than the atmosphere at which tin melts; if we were to have the wire coated with silver, very great care would be required to prevent tin being substituted.

347. Mr. *Fitzroy.*] You were understood to state, that there were some mines in which the lamps were properly looked after?—Yes.

348. Whose business is it to look after the lamps?—There is sometimes a person appointed for the purpose, and sometimes the men take them home and clean them themselves.

349. Each man looks after his own lamp?—Yes.

350. Is there any person whose business it is to see that the regulations of which you have spoken are carried out?—There ought to be always either a fireman or an overman in a mine, or more than one if the mine is a large one, to look after these matters and see that the regulations are properly carried out.

351. In the average number of mines is it so?—In some cases it is not so; and the mines are left without any proper officer being present, and the men may then do as they think fit without detection.

352. Mr. *Child.*] What is the usual course?—In the best managed mines there is always a person left in the pit, and in the worst managed mines there is no person.

353. Mr. *Fitzroy.*] What proportion do the well-managed mines bear to the whole number of mines within your district?—The best managed mines are the smaller proportion; as a general rule, the majority of mines in this country admit of improvement.

354. Then in point of fact, in the great majority of mines within your district, there is no practical check upon the miner opening his lamp whenever he feels so disposed?—I think there is some check; for although in the worst managed mines, the overman or fireman may not be constantly in the pit, he may at all events visit the working once a day; it is very bad indeed where it is not visited once a day, and when he is going his rounds, he would probably at one time or other meet with any person who had his lamp open; and he ought at once to take steps to punish that man.

355. Do the workmen act at all as a check upon each other?—No; you must rely upon your own observation.

356. Are the proprietors of mines aware when your visits of inspection are likely to take place?—As a general rule, I do not give them information when I intend to pay a visit; I believe some of the inspectors do.

357. Are your visits of such a nature, and so made, as to enable you to ascertain whether such a practice is carried on in mines or not?—I have met now and then with a lamp open.

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358. Then you can hardly form any idea of the extent to which the practice prevails?—When an accident happens the fact comes out; and it very frequently appears that the men have had their lamps open, contrary to their instructions.

359. Then is it your impression that that practice does prevail to a great extent?—I have no doubt of it.

360. *Chairman.*] Do you think it desirable that in any case where a safety lamp is required to be used, the miner should take it home and clean it himself?—You generally find that the gauze of the lamp is better cleaned and the gauze much brighter when a man is allowed to take it home.

361. Suppose there was any defect in the lamp?—The gauze ought to be examined every morning at the pit head, before it is taken into the pit. At many mines, they leave the oil can in the lamp room; and the man is allowed to take the gauze home and clean it himself; and, in some cases, a premium is given to the person who keeps the cleanest gauze; and in these cases the lamps are very well cleaned.

362. On bringing the lamp back, it is always necessary, before the man enters the pit, that some proper person should inspect the lamp, and see that there is no defect in the gauze?—When the oil can is screwed to the gauze, it ought to be the duty of the lamp-man to examine the gauze, and see that it is all right.

363. Is that always done in every colliery?—It is generally professed to be done.

364. Supposing it were not done, and an overman in going round the pit were to see a man burning a lamp, he could not tell from his own observation, without an examination of the lamp, whether there was a flaw in the gauze or not?—It is quite possible that an overman might overlook such a lamp in going his rounds; I have met with defective gauzes when I have been inspecting. A person should be appointed to the duty of inspecting the lamps every morning before they are used, and the collier should also be held responsible for the efficiency of his lamp.

365. Mr. *Fitzroy.*] Could an overman doing his duty overlook the fact of a miner's lamp being open?—No.

366. Has an overman any other duties to perform except to superintend the workmen?—He has to look after the ventilation and general working of the mine; and he or the viewer measures the narrow work, which is paid for by measure.

367. Do you think that the safety of workmen would be much assisted by appointing either an additional overman, or by limiting the duties of the overman simply to the superintendence of the workmen?—I do not think you could make such a division of labour in a mine; the overman is also responsible for the carrying on of the mine.

368. If that part of his duty were devolved upon some one else, would he not have more time and more opportunity of securing the safety of the workmen, by preventing their opening their lamps, and exposing themselves to danger?—In some collieries there are a number of overmen and firemen employed.

369. In those collieries do accidents occur as frequently from the carelessness of workmen, as in collieries where a smaller number are employed?—Where the men are more looked after there are generally less accidents than where they are allowed to commit breaches of discipline with impunity.

370. Then, in point of fact, one element which you would recommend, as contributing to the safety of mines, would be a more careful superintendence?—No doubt that is a most important point.

371. Mr. *H. Vivian.*] Do you consider that the law, as it exists at present, is sufficiently stringent in punishing men who are guilty of an infraction of regulations?—If the Act of George the Fourth were generally administered, it seems to be quite sufficient to meet the case. Three months' imprisonment is a long term for opening a lamp; but the magistrates are not unanimous in their administration of the law on that point. If the law were properly administered I think it would be sufficient.

372. You say that in some cases the magistrates convict, and in others they do not convict; do you consider that the law is sufficient to punish men who are guilty of such offences?—I apprehend it must be sufficient, otherwise those magistrates who convict must be exceeding their duties.

373. Mr.

373. Mr. *Child.*] Have there been any appeals against decisions?—I am not aware; a conviction took place very recently in Lancashire.

374. Mr. *Cobbett.*] Have you attended before magistrates when such complaints have been made?—Yes.

375. Do you know the reason that magistrates have refused to convict?—I have not attended when magistrates have refused to convict.

376. Mr. *Fitzroy.*] Does not the carelessness on the part of the miners arise very much from a recklessness of danger?—By constant exposure to danger they become hardened to it, and do not take proper precautions.

377. Do you think that a man who is so reckless of his own life and the lives of those who are working with him as to expose the flame of a lamp, will not be equally reckless at the risk of three months' imprisonment?—I think if there were an apprehension of punishment by imprisonment it would act as a greater check, because no man, on going into a mine, expects that he is going to be killed; although they do not take proper precautions, they expect that no accidents will happen; but if they knew that upon their being found with an open lamp, they would be liable to imprisonment for three months, I believe it would have a very salutary effect.

378. Mr. *Farrer.*] Are the men generally aware of the risk which they run?—I do not think they consider they are running any risk.

379. Are any special instructions given to them, on first going to work in mines?—In some cases.

380. Not generally?—Not so generally as they ought to be.

381. They begin frequently very young?—Yes, as boys.

382. As they advance in years, and find that no accidents occur, do they suppose that no accidents will occur?—I think that is the ground on which a great many of them act.

383. Mr. *H. Vivian.*] With regard to smoking in mines, does it occur that men draw the flame through the wire gauze in order to light their pipes?—Yes.

384. Do you think that any power could be given, either to inspectors or owners of mines, to insist upon smoking not being carried on in mines, and that upon an infraction of the regulation a fine should be imposed?—There is no difficulty in preventing smoking, if the manager will take proper precautions; but if the manager and the overman wink at men when they are smoking, it becomes a common custom among them. In a Newcastle pit, no man dare take a pipe underground with him; he is at once either fined a sovereign, or discharged if he refuses to pay the fine. If you keep up discipline among the men you may easily prevent smoking; but if the overman finds a man smoking, and he does not at once notice it, it creeps into a custom.

385. Mr. *Cayley.*] Is the fact of men lighting their pipes through the gauze, any very particular test that the flame will not come through the gauze?—I think it is possible to light tobacco without drawing the flame through the gauze.

386. You think that tobacco will light without the flame coming through the gauze?—Yes.

387. Mr. *H. Vivian.*] In placing a pipe to the lamp do you not create a very strong draught?—It cannot be very strong, when you consider the small tube through which you draw it, and the very large surface that is exposed.

388. You are aware that it was pointed out by Sir Humfrey Davy, that a strong current of flame would pass through the gauze?—Yes.

389. Mr. *Cayley.*] Then the lamp is not to be considered an absolute security, under all circumstances?—Not under all circumstances.

390. At what rate of current would you say there was a chance of explosion through the meshes of the lamp?—Eight miles per hour; I do not know that that might cause an explosion through the gauze; but I think that no prudent person would expose a lamp in an explosive atmosphere to a current running at that velocity.

391. Supposing the flame was lengthening, and the man apprehended danger, and were to run away, would not the current be so much increased as to produce an explosion?—No; not if we suppose that the flame is merely indicating fire-damp, and has not arrived at the explosive mixture.

392. Suppose he was carrying a lamp with him?—You assume a case where you have not arrived at an explosive mixture, but merely a case between an explosive mixture and one which is non-explosive.

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393. Suppose the atmosphere were such as to indicate danger by the lengthening of the flame, and an explosion not to have occurred?—Such atmospheres are very common, without being explosive.

394. *Chairman.*] Is there not a mode of putting out the lamp?—Yes; you can draw the wick down into the tube.

395. Supposing a man were properly instructed, is it likely that he would run away when he has got his lamp in an explosive state, and would he not be much more likely to put the lamp out?—If he got into such an atmosphere as is spoken of: an atmosphere which was not explosive, but merely indicated the presence of gas, he would at once put his lamp out by drawing the wick down into the tube; but supposing he got into an atmosphere which was explosive, and he had a common Davy lamp with him, and the gauze became full of fire-damp, he might draw the wick into the tube, but so long as the flame was fed with gas it would still continue burning in the cylinder; and as long as that flame continued to burn it would be impossible to put it out without retiring from the explosive mixture.

396. Mr. *H. Vivian.*] Then, in that case, by shielding his lamp, he would prevent any current of air passing through it?—He might put it under his coat and retire. The Museleer lamp becomes extinguished immediately that an explosion takes place in it, and so does the Eloin and the Stephenson lamp.

397. And the Clanny lamp also?—I think it is possible in an explosive mixture to keep up flame in the top of the wire-gauze tube.

398. Mr. *Cayley.*] If the air was in an explosive state, and the man should not have that presence of mind, which is not very common in danger, would his running or stumbling, or any accident of that kind, produce the very explosion which the lamp is intended to prevent?—It might; but we are now imagining cases which ought never to happen, and which do very rarely happen.

399. Have you not attributed some of the explosions to the fact of the miners being indiscreet in opening the top of their lamps?—That is another thing.

400. Is it not possible that an explosion, when no evidence has been given on the subject, may have taken place from these circumstances?—In the course of my experience I have only met with two cases where the gas appeared to have fired through the gauze.

401. If an explosion took place twice under the circumstances you mentioned, what reason is there to prevent its occuring a greater number of times?—No reason; only that the ventilation of the mine ought to be better attended to; the mine ought not to be allowed to get into such a defective state.

402. You think that greater dependence should be placed on the ventilation, than upon anything else?—I would use the safety-lamp as a precaution against outbursts of gas, either from some sudden irruptions from the roof, or floor of the mine, or from the seam itself, and also against sudden irruptions from goaves or other accumulations.

403. As a general principle, may it be assumed that you consider the best source of safety to consist in improved ventilation?—Yes; but even with good ventilation a mine might be liable to the circumstances which I have mentioned.

404. But the better the ventilation the less liable it would be to those circumstances?—No doubt.

405. Mr. *Farrer.*] Do you see any objection to having the lamps locked, so that they cannot be opened in the mines?—I think all lamps should be locked.

406. Are they in general locked?—In some cases they are locked.

407. You see no reason why they should not be locked in all mines?—I think they ought to be locked in all mines.

408. If that were done, a great number of accidents would be prevented?—It would often prevent the men opening their lamps who now open them, but it would not in all cases prevent them; the men get keys occasionally.

409. Supposing the overman kept the key, and some person were appointed to lock all the lamps in the morning before the men came to work, would the difficulty be overcome?—Not if a man had a key in his pocket.

410. If he had a key in his pocket how could he open the lamp?—He could open his own lamp.

411. How could he do that without the connivance of the overman?—If strict discipline is carried out, and the overman, on finding a lamp open, makes a point

a point of having the man dismissed, there is no difficulty in keeping the lamps locked; it is only where these matters are overlooked that lamps are opened.

412. Mr. *H. Vivian.*] If there were a specific enactment for punishing men, in case of their endangering the lives of their fellow-workmen by opening their lamps, or smoking, do not you think a great moral effect would be produced?—No doubt.

413. Mr. *Cayley.*] Do you think that the system of inspection in Belgium at all diminishes the sense of responsibility on the part of the owners of mines?—No, they are still left responsible.

414. *Chairman.*] In Belgium, is the system of splitting the air understood?—Yes; the air is very well split.

415. Is there any peculiarity with regard to the system of ventilation as to return air?—That is particularly attended to in Belgium. Every vitiated current must continue to rise until it reaches the up-cast shaft.

416. The air is not allowed to go up one way and down another?—No; not without the formal consent of the inspector, which is rarely given.

417. Do you consider that is an important principle in ventilation?—Yes, very important.

418. Is it a principle which you would recommend for adoption in this country?—I am afraid you could not make it imperative in this country. In working fire-damp mines in Belgium, where the seams are very steep, it is one of the Government regulations that, in the first place, the upper range must be worked, and so on in descending ranges of about 30 yards each, leaving the upper range for the return air-course; so that as the pit is sunk to a new level at each 30 yards, that which was the deep level of the former working becomes the level for the return air of the deeper working. In our flat seams of this country, or where the dip is one in 20, or in 12, or one in 6, it would add very much to the expense of getting the coal, to render it illegal to bring the air-current down again.

419. Mr. *H. Vivian.*] Assuming that you have a 50 fathom pit to your rise, and a 250 fathom pit to the dip, and that that deep pit is heated to a very great extent, would you not gain enormously by taking your air down to that pit, and taking it up in a highly rarefied state rather than allowing it to go up the 50 fathom pit?—Under such circumstances you would gain by the rarefaction, but it would not be acting in accordance with nature.

420. *Chairman.*] And therefore you think that adherence to this principle in Belgium is not always beneficial?—I think it ought to be attended to in every case where it is practicable; indeed, in this country, where it is practicable it is generally attended to; but it is not practicable in every case. I do not think it should be made compulsory.

421. Can you state the number of persons who have lost their lives in coal and other mines in Belgium during a period of five years ending 1849?—During the five years ending 1849, in Belgium, 724 persons lost their lives in the coal and other mines, being an average of 144⅘ lives per annum. They took place as follows:—

	TOTAL LIVES LOST.
In Shafts:	
By ropes and chains	84
By ladders	20
Miscellaneous	94
	198
Falls of roof and sides of workings	240
Explosions of fire-damp	138
Inundations	6
Explosions of gunpowder	13
Miscellaneous	129
TOTAL	724

The average number of persons employed at the mines during the above period was 51,352. The loss of life was consequently at the rate of 2⅘ lives per annum

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per 1,000 persons employed. Most of the accidents happened at the coal mines. The quantity of coal raised during this period averaged 5,055,196 English tons per annum. During the years 1851 and 1852 about 54,000 persons were employed, and the loss of life averaged 194 ½ per annum; there having been two great accidents by explosions of fire-damp in 1852, in one of which, at Longterne Ferrans, 69 lives were lost; and in the other, at Longterne Trischer, 35 lives were lost. The loss of life for 1851 and 1852 is as follows:

	1851.	1852.
In Shafts:		
By ropes and chains	9	26
By ladders	1	8
By miscellaneous	16	25
	26	59
Falls of roof and sides of workings	56	57
Explosions of fire-damp	17	106
Inundations	-	16
Explosions of gunpowder	2	2
Miscellaneous	20	28
TOTAL	121	268

The loss of life in all the Belgian mines for 1851 and 1852 was at the rate of 3 $\frac{6}{10}$ lives per annum per 1,000 persons employed. In all the Prussian mines, during the years 1847, 1848, 1849, 1851, and 1852, the accidents were at the rate of 1 $\frac{64}{100}$ lives lost per annum for every 1,000 persons employed. Taking tne coal mines alone, the average is two lives per 1,000 persons per annum.

[*The Witness delive red in the following List:*]

LIST of ACCIDENTS in COAL and other MINES in *Prussia* during the Years 1847, 1848, 1849, 1851 and 1852, furnished by Mr. *Von Carnall.*

NAME of DISTRICT.	Number of Persons Employed.	NUMBER OF LIVES LOST.								Rate per 1,000 Persons Employed.
		Falls of Roof, &c.	By Gunpowder.	Ropes and Chains.	Man-Engine.	Ladders.	In Shafts.	Mis-cellaneous.	TOTAL.	
1847:										
Silesia	13,428	17	-	-	-	1	3	5	26	1·93
Saxony	4,653	3	-	-	-	-	5	-	8	1·72
Westphalia	11,619	17	-	-	-	1	7	-	25	2·15
Rhine	22,044	26	-	1	-	2	6	1	36	1·63
Rüer	502	1	-	-	-	-	1	-	2	3·98
	52,246	64	-	1	-	4	22	6	97	1·86
1848:										
Silesia	12,147	15	-	-	-	-	4	6	25	2·06
Saxony	5,010	6	-	-	-	-	1	-	7	1·40
Westphalia	10,648	13	-	-	-	-	7	-	20	1·88
Rhine	19,101	16	2	-	-	-	8	-	26	1·36
Rüer	550	3	-	-	-	-	-	-	3	5·45
	47,456	53	2	-	-	-	20	6	81	1·71
1849:										
Silesia	11,550	6	-	1	-	1	11	2	21	1·82
Saxony	5,061	1	-	-	-	1	2	-	4	0·79
Westphalia	12,122	17	1	-	-	-	3	-	21	1·73
Rhine	18,846	9	1	-	-	1	7	-	18	0·95
Rüer	637	2	-	-	-	-	-	-	2	3·14
	48,216	35	2	1	-	3	23	2	66	1·39

NAME of DISTRICT.	Number of Persons Employed.	NUMBER OF LIVES LOST.							Ratio per 1,000 Persons Employed.
		Falls of Roof, &c.	By Gunpowder.	Ropes and Chains.	Man-Engine.	Ladders.	In Shafts.	Miscellaneous.	Total.	
1851:										
Silesia	14,216	7	-	1	-	1	6	-	15	—
Saxony	6,829	5	-	-	-	1	4	-	10	—
Westphalia	12,316	12	-	-	-	2	8	-	22	—
Rhine	20,000	27	1	2	-	2	6	-	38	—
Rüer	746	3	-	-	-	-	1	-	4	—
	54,107	54	1	3	-	6	25	-	89	1·62
1852:										
Silesia	14,956	18	-	-	-	-	6	-	24	—
Saxony	7,384	15	-	-	-	-	3	-	18	—
Westphalia	14,086	15	1	1	-	2	3	1	23	—
Rhine	24,000	21	1	-	-	5	5	-	32	—
Rüer	875	1	-	-	-	-	-	-	1	—
	61,301	70	2	1	-	7	17	1	98	1·60

LIST of Accidents in *Prussia* in Coal Mines only, 1847 to 1851.

	1847.		1848.		1849.		1850.		1851.	
	Number of Persons Employed.	Number of Lives Lost.	Number of Persons Employed.	Number of Lives Lost.	Number of Persons Employed.	Number of Lives Lost.	Number of Persons Employed.	Number of Lives Lost.	Number of Persons Employed.	Number of Lives Lost.
Silesia	8,672	26	8,550	25	8,309	21	8,269	18	9,096	16
Saxony	331	-	338	-	360	-	327	-	365	—
Westphalia	11,619	18	10,648	25	12,122	20	13,110	21	12,316	22
Rhine Saarbrück	5,494	8	4,580	4	3,865	1	3,374	5	3,961	6
Rhine Düren	3,400	7	3,309	9	3,126	6	3,177	13	3,247	13

Being an average of two lives lost per annum for every 1,000 persons employed.

422. Belgian mines being more dangerous than Prussian mines?—The Belgian mines are much more fiery than the Prussian mines or the French mines.

423. Mr. *Locke.*] Of the 724 persons who lost their lives during the five years you have mentioned, only 138 were from explosions of fire damp?—Yes, and in 1851, there were 17 from explosions of fire-damp, and in 1852 there were 106 lives lost by explosions of fire-damp, there having been two great explosions.

424. As against 121, the total number of deaths from all accidents in 1851; and as against 268, the total of 1852?—Yes.

425. Mr. *Fitzroy.*] Is the proportion of deaths in Belgium from explosions of fire-damp, as compared with deaths from other accidents, greater or less than in England, with respect to the same classes?—In England, the number of lives lost by explosions of fire-damp in 1851, was 321.

426. And how many in consequence of other accidents?—Six hundred and sixty-three; the total loss of life being 984. In 1852, there were only 261 lives lost by explosions of fire-damp in England, being a reduction of 60.

427. How many from other accidents?—Seven hundred and twenty-five; the total being 986.

428. *Chairman.*] According to the return you have given, 198 lives were lost in going down shafts; will you state whether the mode which is adopted of sending men up and down shafts, is better or worse than the system which is adopted in England?—In some cases the ascent and descent of mines by ropes is forbidden; and ladders, which are considered safer, are resorted to. In some cases, the men must descend by ladders, but are allowed to ascend by a rope; in other cases, both the ascent and descent by a rope is forbidden. The ladders are considered safer than the rope; but I think we should have very great

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difficulty to get men to ascend or descend our deep pits by ladders, and it must be very unhealthy, the work being so very laborious. The following is a list of the loss of life by colliery accidents in England, Wales and Scotland during the years 1851 and 1852, as reported by the inspectors of coal mines.

1851. Accidents. Total.	1852. Accidents. Total.		1851. Lives Lost. Miscellaneous.	In Shafts.	Falls of Roof.	Explosions of Firedamp.	Total.	1852. Lives Lost. Miscellaneous.	In Shafts.	Falls of Roof.	Explosions of Firedamp.	Total.
210	197	In Staffordshire, Shropshire, and Worcestershire	18	75	111	41	245	14	46	134	25	219
135	149	In Lancashire, Cheshire, and North Wales	24	39	48	70	181	25	57	56	91	229
95	117	In Northumberland, Durham, and Cumberland	39	15	32	57	143	43	28	44	38	153
75	90	In Yorkshire, Derbyshire, Nottinghamshire, Warwickshire, and Leicestershire	8	23	28	76	135	20	30	34	24	108
99	112	In South Wales, Monmouthshire, Gloucestershire, and Somersetshire	20	41	54	15	130	55	26	57	78	216
83	57	In Scotland	8	28	52	62	150	13	20	23	5	61
697	722		117	221	325	321	984	170	207	324	261	986

Taking the annual output of coals at 47 million tons per annum, the loss of life is at the rate of one life per 47,715 tons of coal.

429. Mr. *Locke*.] How does it happen that so large a proportion of persons are killed in the shafts in Belgium, if ascending and descending by ropes is prohibited?—Many shafts are not walled. A stone may fall from the side of the shaft.

430. Do you think it is a principal stipulation on the part of the Belgian authorities, to restrict the men from ascending and descending by means of ropes?—Their new pits are fitted with guides, and in those cases I do not think it is a prudent stipulation; but in the great majority of cases, the winding is by large buckets slung in chains; these buckets are liable to catch each other in passing, which may throw the men out; under the latter circumstances I think it is judicious. I should not go down such a pit myself unless I had business to take me there.

431. Mr. *Cayley*.] Would you consent to go down a deep pit with a chain and no rope?—I do not object to go down deep pits with flat chains, where there are three links, if the machinery is strong; but with a single link chain I do strongly object to go down. I am obliged to do it sometimes, but I do it with great reluctance. Where the manager is a competent man, and goes down the pit himself, you seldom have a single link chain.

432. Is Mr. Fourdrinier's patent in operation at all?—Yes; it is used in isolated cases.

433. Do you consider that is a great protection from accidents?—I have more faith in good tackle and in good winding arrangements than in Mr. Fourdrinier's arrangement. I think that, with proper attention to the rope, an accident by the breakage of the rope need very rarely occur.

434. You think the rope is safer than any other material?—Yes; either hemp or wire. For deep pits a wire rope seems to be peculiarly applicable. It is lighter than a hemp rope.

435. *Chairman*.] Do many accidents occur in Belgium, from people walking down pits?—A great number of such accidents happen in this country; but such a thing on the Continent is almost unknown. An unfenced pit is almost unknown. Almost every winding pit in Prussia is secured by a railing round all parts of it, except where the trams pass to and from the cage, and even this part is generally secured by having a gate which slides up and down, being balanced by a pulley and weight.

436. Is

436. Is it not perfectly possible to have a cage to drop down on the pit, so that when the machinery is in motion there will be no danger of a man losing his footing and falling down the pit?—It is quite practicable, and is occasionally resorted to in this country, to have a loose frame which the cage lifts up when it comes out of the pit, and drops when it descends; that is an effective precaution against loss of life by falling down pits, which is very common.

437. Mr. *H. Vivian.*] Is there not great danger of the rope jamming?—No; it is merely a loose railing. With regard to my inspection of the continental mines, and also my inspection of mines in this country, there are certain points which I think might be laid down as fundamental rules, and which would be agreed to by the majority of our experienced managers, and which may be carried out in practice; they are as follows: First, every old pit should be properly fenced to prevent persons falling into them, some lives being lost from this cause every year; the unfenced old pits in Staffordshire, Shropshire, Worcestershire, and Denbighshire are a disgrace to this country, and the apathy with which they are viewed is almost incredible. Second, the mouths of working pits should also be fenced as far as practicable; this may be effectually done by a light railing, to be lifted by the cage as it ascends, and dropped as it descends; an arrangement of this kind would also save a number of lives annually. Third, pits should be all walled or cased from the top to the bottom; this adds little to the expense of a pit when being sunk, and lives are now annually thrown away by falls from the sides of shafts. Fourth, the use of guides should be enjoined, as far as practicable, when men ascend and descend; and every cage or skip should have a cover over it to ward off falling materials. Fifth, machinery with broken cogs should be at once replaced by new wheels, some serious accidents having arisen from false teeth becoming loose. Sixth, the ropes should always be once run up and down the pit in mornings to see that all is right before men descend, and the weight of men should never exceed more than half the ordinary weight of coals drawn. Seventh, boys ought not to ascend or descend unless accompanied by a man. Eighth, no one should be allowed to come up on full tubs, or to descend by an engine which is drawing full tubs up either the same or any other pit. Ninth, single link chains, except a few feet at the end of the rope, ought also to be forbidden for the ascent and descent of men, and the rope used for winding up the shaft ought not to be used for winding with from the dip, or along the galleries of the mine. Tenth, the shaft-ropes should be constantly watched by the banksman, or some appointed person at the pit-head; with ordinary care in this respect, accidents by breakage of ropes may almost invariably be prevented. Eleventh, an adequate supply of pitwood to be provided, and the overmen enjoined to see that sufficient of it is fixed. Twelfth, every winding-engine should have an indicator to give warning by a bell, when the cage is near the top and bottom of the pit. The boilers, also, in addition to one open safety-valve, should be provided with one safety-valve under cover, accessible to the principal engineer, or manager only. There should also be a whistle to indicate the height of the water, and the pressure of steam when in excess; also a float, to show the height of the water, and a steam-gauge to show the pressure of steam. Thirteenth, with regard to ventilation, adequate ventilating power should be provided; and spacious air-ways, so as not to force the current beyond 500 or at the utmost 1,000 feet per minute. Good brick, or stone and mortar stoppings, for preventing leakage. Good air-doors, and to have at least two doors where the arteries of ventilation are crossed; to have the air bratticed close up to the face of the workings; and if a place has to be left standing, it should always be first cut through and permanently ventilated to the face. In critical cases, where there are accumulations of fire-damp in goaves, or other parts of the mine, which might ignite at the furnace, the furnace should be fed with fresh air; and in very fiery mines, liable to give sudden discharges of gas, the furnace should be fed with fresh air, until the workings had advanced a sufficient distance from the up-cast shaft. Safety-lamps ought also to be used exclusively under such circumstances, and no one but a competent person allowed to fire shots. Fourteenth, the regulations of every mine should be laid down in a good code of printed rules; and there should be a competent manager, good overmen, and firemen, whose duty it should be to see each place safe before a workman entered it; and one or more of whom should be always present in the mine to keep all right during working-hours, and whose duty it should be to see that the mine continues safe, and to report breaches of discipline to the manager.

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438. Mr. *Cayley.*] Is it your opinion, upon the whole, that the Belgian system can teach us more on the subject of inspection than on the subject of ventilation?—As a general rule, I think our best managed mines are better managed in this country than the mines in Belgium, or any of the continental mines.

439. What is your opinion with regard to inspection?—I do not think the mines of this country require the number of inspectors which the continental Governments have for their mines, for the reason I have stated; namely, that they have other matters to look after, and that in this country we have a more experienced class of managers in our collieries.

440. With regard to the size of the districts, and the number of inspectors, and the powers which are given to the inspectors, do you think that any improvement could be introduced from Belgium?—I have given an outline of regulations which I think will be agreed to by experienced men. I think if those regulations were made compulsory, and upon an accident happening from the want of such provisions a punishment was inflicted, either by fine or imprisonment, the present number of inspectors, or a very moderate increase of the number, would be quite sufficient for all the wants of this country, and would tend very much to diminish the number of accidents which take place.

441. Mr. *Locke.*] Does the Table you have put in specify the accidents which arose, in Prussia, from fire-damp?—There is very little fire-damp in Prussia, and the few accidents which have occurred from fire-damp are included under "Miscellaneous."

442. The accidents which are given in the Table you have put in, arose chiefly in the shafts, from the use of ladders, and by the falling of roofs?—Taking the year 1852, there were 70 lives lost, in Prussia, from falls of roofs; by explosion of gunpowder, two lives were lost; by ropes and chains in the shaft one life was lost; accidents by ladders in the pits, 7; other accidents in shafts, 17; miscellaneous, 1.

443. So that, during that year, there being only one "miscellaneous" life lost, the loss of life arising from fire-damp may be said to have been nil?—In the return which was furnished by the principal minister, it is not clear whether the explosions come under the falls of roof, &c., so that there may be more than one, but he stated to me in a letter that the number was so small as not to be worth separating.

444. Mr. *Fitzroy.*] In your opinion, does that arise from greater precautions with respect to fire-damp, or from the absence of fire-damp itself?—From the absence of fire-damp. The precautions in Prussia, with regard to ventilation, are very slight indeed; the majority of the mines are carried on by natural ventilation.

445. *Chairman.*] Is there anything in the Prussian system which you can recommend this Committee to adopt, as preferable to the system which is adopted in England?—Nothing except the fencing of the pits, which I have alluded to. In other respects, I think we are very far in advance of them.

446. With regard to the system of Prussian inspection; can you state the system of inspection in Prussia?—There is one inspector-general, who resides in Berlin; four principal directors; 12 local directors; about 35 burgmasters; and a large number of officers who are called sworn miners. This staff is recruited from a class who at 18 years of age work a year in the mines; they then go to college for three years, which is succeeded by another three years work in surveying, &c., in the mines; and then, at about 26 years of age, on passing the several examinations, they are eligible for the lowest offices, or they may go into other occupations; they may rise and become directors; but it is necessary to pass another examination before they can do so. In Prussia, also, the inspectors are not solely engaged in looking after the safety of the mines and the welfare of the workmen. An important part of their duty consists in looking after the per-centage payable to their Governments, and in verifying the plans.

447. Are the inspectors generally a well educated and scientific class of men?—Yes; their previous education ensures that.

448. Mr. *Locke.*] With that staff, the Government are the owners of the mines?—They stand in a similar position to a lessor in this country.

449. They lease the mine?—They do not exactly lease it; the minerals are at the disposition of the Government.

450. Will you state in what relation the Government stand to the proprietors of the mines?—The law of Belgium recognises the right of proprietors of minerals, and in Prussia also, in certain cases.

451. Subject

451. Subject to any payment?—In Belgium about 2½ *d.* per acre is in all cases paid to the proprietor of the minerals. In Prussia, the Government receives 5 per cent. of the profits from one portion of the kingdom, and 5 per cent. of the produce from another portion of the kingdom. There are properties in Prussia which belong to private individuals; and, in these cases, the mines are subject to Government inspection; but the Government receive no portion of the profits. Very few mines of this description belong to private individuals, compared with those where the profits are at the disposition of the Government.

452. The great bulk of the mines are held in that way by the Government?—In Belgium they are all at the disposition of the Government, and they receive 2½ per cent. of the profits. Surface damages are in all cases paid to the proprietor of the surface, and in some cases he is paid double damage.

453. *Chairman*] Did you visit also any mines in France?—Yes.

454. Did you visit mines in the Valenciennes district?—Yes.

455. How did you find the mines in those districts carried on?—The mines are worked very well; the seams are thin and the accidents very few. During the five years ending 1851, there were only 49 deaths in an average of 9,375 persons employed, being an average of 9 $\frac{8}{10}$ deaths per annum, which is 1 $\frac{04}{100}$ lives per annum per 1,000 persons employed.

456. Are they fiery?—They are not fiery.

457. Did you visit the large coal fields at St. Etienne and Rive de Gier?—Yes.

458. Did you find the mines in those districts also well carried on?—With regard to the working of a thick coal by the system of long work, I think it is an admirable system; but, in other respects, such as the winding arrangement and the ventilation, it is very rough.

459. Is the loss of life very great?—Very great; in 1852, the total number of persons employed at the coal mines in this basin, the Loire basin, was 6,703, of whom 4,780 were employed under ground. The loss of life during the year was 42, being at the rate of 6 $\frac{26}{100}$ lives per 1,000 persons employed; 22 of the lives were by falls of roof; 19 by shaft accidents, and one by gunpowder. The quantity of coal raised in this basin during this year, 1852, was 1,534,588 English tons; the loss of life was therefore at the rate of one life per 36,538 tons of coal raised.

460. Do you think there is anything in the system of working mines in France, which this Committee ought to recommend as an improvement in working mines in England?—I think the long work system of working thick coal at St. Etienne might be introduced into Staffordshire in the working of the thick coal.

461. Mr. *Child.*] South Staffordshire?—Yes.

462. *Chairman.*] Is there any particular system of inspection in France?—Yes; they have a system similar to that which is adopted in Belgium and Prussia.

463. The Government having an interest?—The Government having five per cent. of the profits.

464. Mr. *Locke.*] Is there any other place in France, besides St. Etienne, where thick seams of coal are worked?—Yes; in the South of France there are several.

465. Do they work in the same manner in those places as they do at St. Etienne?—Not always; it is worked different ways at St. Etienne.

466. Can you state the reason why they do not work in the improved mode which is adopted at St. Etienne?—The other way is considered an improved mode also. I have prepared a drawing of this mode of working, and Mr. Mackworth has prepared a drawing of the other system of working.

467. Can you form an individual opinion as to which is the best?—I prefer the system of long work which is adopted at St. Etienne.

468. Can you give the Committee any reason why the French authorities have not insisted on one uniform plan of working similar coal?—No.

469. Mr. *H. Vivian.*] Would not the peculiar character of the seam of coal regulate the mode in which it was desirable to work it; that is to say, is there not a soft part in every coal which it is always desirable to work?—One portion of this seam which I examined was 65 feet thick, and there was no holeing in it; there were solid partings here and there an inch in thickness, but nothing which could be called a soft holeing.

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470. In the case of the Staffordshire thick coal, it is desirable to work certain portions first, owing to the easy nature of the cutting?—There is nothing in the Staffordshire thick coal, so far as the holeing goes, to render it desirable to continue the old system.

471. Then, in your judgment, that system is applicable to Staffordshire thick coal?—I think it is.

472. Mr. *Locke.*] Do you think the system which is adopted at St. Etienne is applicable also to other parts of France where thick coal is worked?—I think it is.

473. Do you think it would be an advantage if this system were adopted there?—I think it would.

Jovis, 16° die Junii, 1853.

MEMBERS PRESENT:

Mr. Hutchins.	Mr. Locke.
Mr. Hussey Vivian.	Mr. Cayley.
Mr. Mostyn.	Mr. Cobbett.
Mr. Stephenson.	Mr. Farrer.
Mr. Fitzroy.	Mr. Henry Austin Bruce.
Mr. Baird.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Herbert Francis Mackworth, Esq., called in; and Examined.

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474. *Chairman.*] YOU are a Government Inspector of Mines?—I am.

475. How long have you held the appointment?—About 18 months.

476. You were examined before the Committee of 1852?—Yes.

477. You were at that time government inspector of the south-western district?—Yes; and I hold the same district at the present time.

478. In the month of May did you receive instructions by letter that you would be called before this Committee?—I did.

479. Is the paper now handed to you the letter which you received (*handing a paper to the witness*)?—Yes. [*The witness delivered in the same.*]

480. Have you got a tabular statement of the accidents which occurred in the coal mines of Great Britain in the years 1851 and 1852?—I have. [*The witness delivered in the same.*] Taking the number of lives lost in the coal mines of my district in 1851 and 1852, I find that there is a considerable diminution in accidents in shafts; accidents in shafts, and accidents from explosions of fire-damp, being those on which inspection would naturally have the most effect. In accidents from explosions there is a considerable increase in the number of deaths, owing to 65 lives being lost by one explosion at Middle Dyffryn.

481. When did that explosion take place?—On the 10th May 1852. The considerable increase in the number of deaths from "miscellaneous" accidents, is owing to irruption of water at the Gwendreath Colliery, by which 26 lives were lost, and this accident occurred on the same day; an accident of the kind had not occurred in the district for a long time previously. I find in the total number of accidents in Great Britain, there is a considerable diminution of the deaths in shafts in the year 1852, as compared with the year 1851, and also in the number of deaths from explosions of fire-damp.

482. How do you account for the decrease in the number of shaft accidents?—I think that, to some extent, it must be due to the inspection, because during this time there has been a considerable increase in the quantity of coal produced; and if you take the falls of roof (a class of accident upon which we are not able to produce so much effect), and the increased deaths which have occurred from that cause, I think the diminution of those accidents upon which the inspection can have most effect will appear in a more decided light.

483. Mr. *Fitzroy.*] How many different collieries did you inspect in the year 1852,

1852, when, as you state, there was a great decrease in the number of shaft accidents?—I inspected from 90 to 100 different collieries, as near as I remember, and to some of these I went several times.

484. *Chairman.*] During that period, has there been an increase in the production of coal?—A considerable increase.

485. Can you state the difference of production?—As near as I am able to form an opinion, the increase may be taken at five per cent.

486. Then of course a greater number of workmen were employed to raise that quantity of coal?—Yes.

487. Can you give the Committee any idea of the number of extra men who were employed during that period?—You may take the ratio of increase at five per cent, and there is a diminution of six per cent. in accidents from explosions and in shafts.

488. You attribute a good deal of the result to the present system of inspection?—I think it is due to it.

489. Mr. *Locke.*] Are you aware that any orders have been issued by the inspectors, which justify that conclusion?—I judge from the improvement that I have seen in a great many collieries, where I have made suggestions which have been carried out.

490. Is there any order in existence which was issued by an inspector, in reference to accidents in the shafts themselves?—We have not the power to give an order.

491. Have you seen any defects in any of the collieries that you have visited, with reference to the shafts?—A great many.

492. Will you name one?—The Soundwell Colliery.

493. *Chairman.*] Where is that?—Near Bristol.

494. In that colliery what did you find objectionable?—I found the ropes in a bad state; parts of the pits insecure, not properly walled, and I found the men descending in tubs without any cover.

495. Mr *Fitzroy.*] Had there been many shaft accidents in that colliery, before you visited it, and made these discoveries?—There had not been any shaft accidents during the 12 months previously to the time that I was appointed an inspector, and up to the time of my inspection.

496. Mr. *Locke.*] Will you mention any other case in which there has been an accident in shafts, where you have made a suggestion, which has been attended with the benefit which you say you think has arisen from inspection?—I can enumerate many cases: at the Dowlais Colliery, the cage, in ascending, struck against the side of the shaft, and the chain guides were removed, so as to allow it to run clear, and the part of the shaft which was narrowest and got out of shape was rewalled.

497. Were those alterations made by the agents of the collieries themselves, or from your suggestion?—They were made by the agents of the collieries upon my suggestion.

498. To whom did you make the suggestion?—To the manager.

499. Of the Dowlais Company?—Yes.

500. Do you recollect his name?—Mr. Evans.

501. Can you give the number of accidents in that particular mine, during the preceding year, and during the last years?—There had not been any fatal accident there before, during the time of the inspection.

502. Has there been any accident since?—No.

503. Mr. *Fitzroy.*] You state that there has been a great diminution of shaft accidents, owing to the inspection of the Government inspectors: will you give one case where shaft accidents did occur, in which, owing to your suggestions, they have been put an end to?—The two cases I have mentioned I think apply to that, as near as any that I can mention.

504. Mr. *Locke.*] Can you mention any other case?—In numberless instances I have pointed out defects in shafts.

505. *Chairman.*] Can you state to the Committee any case where an accident has happened, and you have gone to the mine and suggested some improvement which has been followed out, and where, in consequence of that improvement, no further accidents have happened?—That is the case in the two collieries I have mentioned.

506. You were understood to state, that in the case of the Dowlais Company, no accident had happened before?—An accident happened at the Dowlais

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Colliery. I examined the colliery at the time of the accident, and made the suggestion which I have described.

507. Mr. *Fitzroy.*] Can you mention any collieries in which you have found the shaft arrangements deficient, and where, in consequence of your suggestion, an alteration has been made in those arrangements, and loss of life has been checked?—I do not recollect, at the present moment, any shaft in my district, where there have been two accidents during the two years.

508. You were understood to state that the number of shaft accidents was very materially decreased, and that you attributed that decrease to Government inspection. To what period do you refer as abounding in accidents, which have been diminished by Government inspection?— I should state, in explanation of my meaning, that the number of lives which been have lost in England, from accidents which occurred from men descending by the ropes, is from four to five in 10,000 persons per year; consequently you will see that the probability is, that an accident might not again happen in the same shaft for many years, on the average. It is very seldom that the shaft is in such a state that accident after accident occurs in it. The inspection has improved some of the more dangerous.

509. Mr. *Stephenson.*] How long have you been an inspector?—A year and a half.

510. Would your experience in that time justify you in drawing any general conclusion with regard to these accidents and the benefit of inspection?—I judge of it in this way; that I have found many shafts in a dangerous state; I pointed it out, and the proprietors have either remedied them or promised to remedy them.

511. Mr. *Fitzroy.*] With what period are you comparing the year 1852, when you say that there was a great decrease in the year 1852 in the number of shaft accidents?—With the year 1851; and at that time the inspection was in existence; but I was only inspector during one month at the end of 1851.

512. *Chairman.*] In your visits round the mines, do you meet with any opposition from coal owners in carrying out your suggestions?—I have not experienced any difficulty in visiting the collieries; and they or the managers have almost invariably promised to carry out my suggestions.

513. Have you found a general willingness to meet your views as much as possible?—Yes.

514. Mr. *Locke.*] How long had you been connected with the management of mines before your appointment as an inspector?—Two years.

515. Where were you employed?—In South Wales.

516. Can you name the colliery?—Mr. Powell's collieries.

517. Mr. *Cayley.*] You have alluded to the loss of life, from explosion, in the Middle Dyffryn Colliery; was that the Aberdare case?—Yes.

518. Since 1845, how many deaths have occurred from explosions in that mine?—I think about 78.

519. How is it ventilated?—The Middle Dyffryn Colliery has a furnace and steam jet to produce the ventilation.

520. How was it ventilated during the time of these explosions?—The furnace was at work; the explosions occurred from the gas igniting the furnace.

521. Mr. *H. Vivian.*] To what do you attribute the great loss of life from explosions in the Middle Dyffryn Colliery?—To the bratticed shaft, and the number of doors and weak points in the colliery.

522. Were there upwards of 20 main doors in the Middle Dyffryn Colliery?—If you include the cross headings, there were.

523. Were all those doors destroyed by the explosion?—Yes, there were that number destroyed.

524. The result of that was, that the distant workings were entirely cut off from any supply of fresh air?—The miners at the bottom of the shaft were cut off from the current of air; it went down one side of the brattice, and returned up the other, passing through the aperture caused by the explosion. With regard to the Middle Dyffryn accident, an important point, which has not been given in evidence before, is the precise manner in which the accident occurred. There was a great discharge of gas, which came off about 300 yards from the furnace. On coming to a point 100 yards from the furnace, there was a regulator, with an aperture about two feet square at the bottom; so that the discharge of light gas, sweeping along the top of the air-way, met this obstruction,

struction, accumulated stratum after stratum (if I may so explain it), and 10,000 cubic feet of air per minute were pressing behind; and when the lower level of this light gas came down to the aperture, hardly anything, naturally, but pure or highly explosive gas would be forced through that aperture—that gas, immediately rising up, would fill the whole of the heading beyond. At a distance of 30 yards only from the front of the furnace, it met the rather larger quantity of air coming from the ventilation of the rest of the mine, and there was not sufficient interval for these to mix, and the stratum of gas reached the surface of the fire.

525. Mr. *Cayley.*] And the furnace was the cause of the explosion?—Yes; it occurred under very peculiar circumstances.

526. There was no dumb drift?—No.

527. Mr. *Baird.*] Was the aperture through which the air passed altered?—It was removed.

528. Mr. *Locke.*] When did that accident happen?—On the 10th of May last year.

529. Were you a Government inspector at the time?—Yes.

530. Had you been a Government inspector before that period?—I had.

531. *Chairman.*] When you gave your evidence on the 9th of June 1852, you put in a statement with regard to the accident?—Yes.

532. The evidence which you have now given is in addition to the statement which you gave at that time?—Yes.

533. Mr. *Cayley.*] Did you point out or advise them before the accident of the imperfect state of the ventilation?—My predecessor had pointed out, upon a previous explosion which occurred there, that it was dangerous to work with anything but safety-lamps in the colliery.

534. *Chairman.*] Who was your predecessor?—Mr. Kenyon Blackwell.

535. Do you agree with him in that recommendation?—Perfectly.

536. Mr. *Locke.*] Would the use of locked safety-lamps in that colliery have prevented that particular accident?—The expression Mr. Blackwell made use of was, that they were not to use naked lights. At the time Mr. Blackwell inspected the colliery, they were using candles, and a lamp in the up-cast shaft, for the purpose of ventilation; at the time the previous accident occurred; he then told them they must not use naked lights in the colliery.

537. Mr. *Stephenson.*] The question has reference to the last explosion which took place?—Yes.

538. Would the adoption of Mr. Blackwell's recommendation have tended in any way to have prevented the accident?—I think if the recommendation of Mr. Blackwell, that naked lights should not be used, had been followed strictly, the accident would have been prevented.

539. The accident took place at the furnace, and not at the lamp?—Yes; the question is, whether a furnace is a naked light or not.

540. Mr. *Locke.*] Did you or Mr. Blackwell ever give any order or make any suggestion against the use of the furnace in that mine before the accident?—No. At the time Mr. Blackwell inspected it, the furnace was not used.

541. During the time of your inspection, were they using the furnace?—Yes.

542. Did you ever object to it?—I had not inspected the colliery; the accident occurred about four or five months after I had been appointed inspector, and I had not been into that colliery.

543. Mr. *Cayley.*] Is it the fact, that before one of the explosions there was a great fall of the barometer?—There was a fall in the barometer on the morning of the explosion.

544. Would not that tend to allow of the escape of the fire-damp from the goaf?—I do not think, taking the appearance of the orifice through which the gas escaped, the thickness of the measures it had burst through, that the barometer had any effect in producing that accident.

545. As a general rule, is it not the fact that a fall in the barometer would indicate the necessity for greater vigilance on the part of the persons having charge of the ventilation?—Theoretically, the fall of the barometer would have an effect in making the gas, if there was an accumulation in the mine, approach more nearly to the working parts.

546. If there was a barometer kept at the bottom of either shaft, and there was a great fall in the barometer in the down-cast, would it not be an indication of danger?—A slight fall in the barometer, at the bottom of the up-cast shaft, might indicate an increase in ventilation, or an increase of fire-damp at the edges of goaves.

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547. Mr. *Fitzroy.*] Was this mine supposed to be peculiarly fiery?—There was not a large constant discharge of fire-damp; its peculiar and very great danger arose from the irregularity of the discharges; a seam of coal several yards above gives off gas from time to time, and I consider it one of the most dangerous class of collieries.

548. It is one of the most dangerous in your district?—Yes.

549. Do you select, for more careful inspection, those mines which are supposed to be more dangerous than others?—As near as I can determine.

550. Which of the mines in your district had you reason to imagine to be more dangerous than that in which this explosion took place?—I think it was about as dangerous as any.

551. How many months had you been appointed a Government inspector before this took place?—Four or five months.

552. Had you visited many mines during that time?—Yes.

553. Is it your custom to select those mines which are most dangerous for your more careful inspection?—Yes.

554. Then how came you to overlook this mine, which you have described as one of the most dangerous, if not the most dangerous in your district?—Because when the previous explosion occurred, my predecessor (Mr. Blackwell) made a very strong report upon the danger of the mine, and the necessity of avoiding the use of naked lights, which was confirmed by the verdict of the jury; and I considered that, under those circumstances, pursuing the course which I have mentioned, this mine did not run so great a chance of accident as other fiery mines in the district.

555. *Chairman.*] With regard to naked lights, you have alluded to Mr. Blackwell's official report, in which he condemned the use of all naked lights; from your present explanation of the way in which the accident occurred in the Middle Dyffryn pits, whether naked lights were used, or whether safety-lamps were used, the accident might still have occurred?—I consider that a furnace is a naked light, and that Mr. Blackwell's caution extended to that; there is a difference of opinion, I admit, amongst engineers on that point.

556. How would you obviate the recurrence of such an accident?—By a dumb drift, or by some other means of ventilation than the furnace.

557. There was no dumb drift in this mine at all?—No.

558. All the foul and pure air came over the furnace?—Yes.

559. Mr. *Locke.*] You consider a furnace to be a naked light?—Yes.

560. Have you made any suggestion against the use of the furnace in any other colliery since that accident?—I have given several cautions.

561. Have you given any suggestion against the use of it?—Yes.

562. Will you name the collieries?—Cwmamman, Tillerey, Risca and others.

563. Any others?—I do not recollect them at the present moment, but I know I have given them to others.

564. Do you consider the use of the furnace in those two mines a dangerous means of producing ventilation?—Yes, if unprotected.

565. *Chairman.*] You mean the furnace without a dumb drift?—Yes.

566. Mr. *Locke.*] In those two mines were dumb drifts applied, or not?—No.

567. With the use of the dumb drift, does your objection to the use of the furnace entirely cease?—Not entirely; with the use of the dumb drift, and with proper precautions, I think it is perfectly safe.

568. Mr. *Cayley.*] Reverting to the ultimate cause of the accident (which was the oozing of the gas out of the fissures of the walls), rather than to the proximate cause (which was the ignition of the fire-damp at the furnace), supposing a barometer had been kept outside the mine, and a great fall in the barometer had been observed, would not that have been an indication of danger?—My opinion is formed upon a list of the great accidents in the north of England, which was given by Mr. Thomas John Taylor, before the Committee of 1849, in which he showed that as many accidents occurred with a rising barometer as with a falling barometer; if I were the overman of a colliery I would consider it a caution, because there is theoretically an increased danger; and I have understood that some persons have observed gases come more out of the goaves on a fall of the barometer. A far more serious danger, and one requiring constant attention, is the falling off in the amount of ventilation, arising from the change of temperature of the downcast shaft, or the neglect or want of skill of the flueman.

569. *Chairman.*] But whether the barometer stands high or low, should there

there not be, at all times, sufficient ventilation to prevent danger of any kind?—Undoubtedly. The cause of the numerous fire-damp accidents in this country is, that the margin between safety and explosion is so exceedingly small—hardly more than one-fiftieth.

570. Mr. *Cayley.*] Your opinion is, that the safety of the mine depends upon increasing the amount of ventilation?—That is one of the precautions. I consider the distribution of the air to be far more important..

571. An increase of the quantity of air properly distributed?—Yes.

572. *Chairman.*] Mr. Blackwell, in his official report, condemned the use of brattices and all naked lights. Were his recommendations attended to?—They were not, in any shape.

573. Do you believe this accident occurred in consequence of those recommendations not being attended to?—If his recommendations had been attended to, in respect of the brattice, the accident would have been attended with a comparatively small loss of life.

574. Mr. *Fitzroy.*] Were you aware before the accident took place, that his instructions had not been followed?—I was not.

575. You agreed with him in opinion as to the necessity of those precautions?—I did.

576. If you had had an opportunity of inspecting that mine, and had been aware that his instructions had not been followed, would you have again urged upon the proprietor the adoption of his suggestions?—Certainly.

577. Do you think that the adoption of those suggestions would probably have been attended with a great saving of life, if not an entire avoidance of the accident?—I have not a doubt of it.

578. *Chairman.*] Is thatcolliery at work at present?—Yes.

579. Have those suggestions been adopted since the accident?—They have. The colliery is worked with safety lamps, and the ventilation is caused by a furnace (the air in the mine passing by a dumb drift), and by the assistance of steam jets, near the top of the pit. I believe, within the last few days, the mode of ventilation has been changed, and that one of Struve's ventilators has been substituted.

580. Was there not sufficient air obtained by the furnace?—No; there was not a sufficient quantity of air.

581. Is it a bratticed shaft?—Yes; and one object of putting up the ventilator was to take the currents of air through separate shafts; to take the down-cast air down the present winding shaft, and inside the brattice, where the up-cast air has hitherto ascended, and to exhaust the up-cast air by the pumping pit.

582. Then, in point of fact, it is one pit having pumps on one side of it, and winding apparatus on the other, with a brattice between?—There is a large shaft, which is divided by a brattice; on one side they wind, and the air goes down into the mine; on the other side, when the furnace and dumb-drift are in action, the up-cast air comes up.

583. Mr. *Cayley.*] On the other side of the brattice?—Yes.

584. There is only one shaft?—There is another shaft which was not made use of; at the present moment, I believe this, which is the pumping-pit, is made the up-cast shaft.

585. Mr. *Locke.*] Which is the pumping-pit?—It is a second shaft, which is now put into communication with the ventilator, and the air descends on both sides of the brattice of the first shaft, which hitherto has divided the up-cast from the down-cast air.

586. Can you state what is the relative area of the up-cast shaft, as employed at present, and the portion of the first shaft, which was bratticed off at the time of the accident?—In the former case, the area of the up-cast part of the shaft was 82 square feet, and the present up-cast shaft has a diameter of nine feet six, and an area of 70 square feet.

587–8. In your investigations, did you find, at the time the accident occurred, that the instructions respecting the use of naked lights in the pit had been attended to, or that naked lights or safety-lamps were used?—They were using naked lights at the time the accident happened.

589. Mr. *Stephenson.*] In spite of the instructions they had received from the inspector?—Yes.

590. Mr. *Cayley.*] Was that fact brought out at the coroner's inquest?—Clearly.

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591. Did that wilful neglect cause any additional penalty to be levied?—There was a verdict of accidental death.

592. Under the circumstances, do you consider that was a satisfactory verdict?—There were several colliery engineers there, who were not examined on oath, but whose opinions were taken; and with the exception of one person, who had been consulted about the continuation of the use of naked lights, they all stated that safety-lamps ought to have been used.

593. Mr. *Locke*.] Will you state whether, at that investigation, the explanation you have given in reference to the stopping and the use of the aperture, was brought before the jury?—It was not. I visited the colliery several times afterwards; and it was not until the colliery was again in working order, that I received the explanation about the stopping. It was blown out at the time I went through it.

594. As I understand your former answer, you are of opinion that that accident arose from the fact of an accumulation of gas, owing to the aperture being placed at the lower part of the stopping, upon which that accumulation rushed on to the furnace, and exploded. Is that the opinion which you have formed with reference to the cause of that accident?—Yes; that is the opinion I now hold; 70 yards of the heading became filled with gas, so that the explosion took place at the furnace. It is just possible that the gas might have gone over the furnace without exploding, if the aperture had not been in that position.

595. If that aperture had been at the top of the stopping, instead of the bottom, are you of opinion that the gas would have passed over the furnace without an explosion?—I think that the explosion would have occurred, if the aperture had been wholly at the top. The aperture ought to have extended up on one side. If the aperture had been at the top, the nearly pure gas would have gone through, nearly in the same way.

596. Without accumulation?—Without quite so much accumulation.

597. What effect do you attribute to the accumulation of the gas before it reached the furnace, instead of allowing it to pass, as it was generated in the goaf, over the furnace?—The accumulation brought the gas down to the level of the fire as it passed over.

598. *Chairman*.] If there had been a dumb drift, which would have taken that quantity of foul air at a sufficient distance above the furnace, in your opinion would the accident have taken place?—I do not think there would have been a chance of the accident occurring.

599. Mr. *Stephenson*.] Then, in point of fact, the accident arose from an improper application of the furnace?—Yes.

600. And it does not form, in your mind, any objection to the furnace system of ventilation?—Not as long as the furnace is used with the dumb drift.

601. Mr. *Cayley*.] You have stated that the safety of the mine depends very much upon the ventilation; how often can you visit the mines in your district?—It would take me four or five years to go round them once.

602. What test can you have between each visit of the state of the ventilation in your absence?—No test whatever.

603. Can you suggest no means of ascertaining what amount of ventilation there has been during your absence?—I cannot suggest any test which I could rely upon.

604. Then you consider that an inspector must remain in entire ignorance of the state of the ventilation during his absence?—Yes.

605. If inspection is to be of any use, do you consider that there are a sufficient number of inspectors?—I seldom give notice before going to inspect a colliery; and that is a certain check, although it does not amount to a test. I am now pretty well acquainted with the most dangerous collieries in my district, and to those I direct most attention. I require assistants to carry out the inspection effectually.

606. If you hear of a dangerous pit, and upon visiting that pit you find there is anything deficient, do you make recommendations?—Yes.

607. After making those recommendations, do you repeat your visit at some sudden and uncertain time, in order to see whether your recommendations are carried out?—Occasionally I do.

608. Do you consider the anemometer to be of no use?—I test the ventilation in every colliery by it, where there is a current of air sufficient to move the anemometer with the instrument; but there are many cases where the current of ventilation is not sufficient to give any indication on the anemometer.

609. If

609. If the current of air was insufficient to move the anemometer, would it be sufficient to dilute the gas, or would it be healthy for the miner?—It would not.

610. Then if the current was not great enough to affect the anemometer, that would be an indication that the ventilation was insufficient?—Yes; I have always represented it as being very insufficient.

611. Have you any reason to believe that an anemometer could not be made to be self-registering; so that during your absence there might be a register of the amount daily?—I believe such an instrument has been made. I have not seen it in action; but I could hardly depend on the indication of the anemometer, because the air-ways are either altered, or may be altered from time to time, so as to affect very materially the results indicated by it.

612. If the owner of a mine, or the overlooker of a mine, wished to deceive an inspector, he would split the air in the galleries, so as to create a greater current past the anemometer?—It might be done.

613. But if it was the interest of the working miner that there should be a sufficient amount of ventilation, and a handsome penalty was leviable upon the owner for such a transaction, do you think the owner would dare to resort to such a proceeding?—I think he might without the miner's giving information.

614. *Chairman.*] Do you think there are not means by which the manager of a mine could deceive an inspector, provided the anemometer were in the most perfect state that ingenuity could invent?—There are means.

615. Mr. *Locke.*] You would not be disposed to rely entirely upon an instrument of that kind?—No.

616. That is, yourself, as an inspector?—I should not rely upon it.

617. I presume you would not be an advocate for the introduction of an instrument which might, at all events, weaken the vigilance of the overlooker of the mine, on the part of the owner?—No, if that were the effect.

618. *Chairman.*] Is it not often the case that the overlooker will deceive the owner himself?—Yes.

619. If you had an overlooker who was not an honest man, is it not possible that, contrary to the express order and wish of the owner, he might endeavour to deceive the inspector?—Yes.

620. If he did endeavour to deceive the inspector would there be any possibility of preventing him?—In some respects he might deceive the inspector.

621. Mr. *Cayley.*] Has not the working collier himself a strong interest in the safety of the mine?—Yes, but I believe colliers are bad judges of ventilation.

622. Is it or not the fact, that the working collier himself has a strong interest in the efficient ventilation of the mine?—Yes, but he is seldom sufficiently attentive to it.

623. Supposing it were understood that a self-registering anemometer was intended to be the test of the state of the ventilation during the absence of the inspector, if the working colliers saw that any tricks were played with that anemometer, in creating an artificial increase of current past the anemometer with a view of deceiving the inspector, would it not be the interest of the working colliers, or of some of them, to give intimation of such a circumstance?—I can only judge of that by the fact, that in much more important cases, where the safety of the mine is concerned, the working colliers do not come forward and give us any information.

624. If there was a punishment on such a transaction, and the working collier had a large reward for giving information, would not that be the probable protection for the use of and a test as an anemometer?—I think that not one in a hundred of the working colliers would understand anything about it; and I think that even a large reward would not induce them to give information to inspectors.

625. Then, at the present moment, you have no indication of the state of the ventilation during your absence?—None.

626. Would not you rather have an instrument which gave you some indication of the ventilation than have no means of ascertaining the state of the ventilation during your absence?—There would be some advantage in having an instrument of that sort; I should be glad to see some instrument of the kind, because it would show me that some attention, at least, was paid to the amount of ventilation in a colliery, which, I regret to say, is not often the case.

627. Mr. *Stephenson.*] The volume of air is by no means a criterion of its perfect utility?—The point in which the collieries in England are most deficient

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is in the distribution of the air; and there might be a large amount of air at the bottom of a shaft, which would give a false indication of security.

628. Mr. *Locke.*] What would be the use of an instrument of the kind that has been alluded to?—I do not think there would be much use in an instrument of the kind.

629. Mr. *Cayley.*] If there were not a sufficient amount of air going into the mine, what would be the use of any method of distribution?—It is important to get a considerable quantity of air into a mine, because then it can be distributed comparatively easy.

630. The fact being, that the first essential of ventilation is to get a sufficient amount of air, and that the next is to distribute it properly through the various workings of the mine?—The first step is to get the air, and the next is to distribute it.

631. Mr. *H. Vivian.*] Do you find that the ventilation in each particular mine in your district varies materially, from visit to visit?—As much as one-fifth in some instances.

632. May not that depend on the state of the thermometer and barometer, and upon accidental causes?—I think the difference of the temperature of the atmosphere between the morning and the middle of the day, when there often occurs a considerable variation, will produce an alteration of one-sixth in the amount of ventilation in collieries, if it is not provided for.

633. Mr. *Locke.*] You mean the volume of air passing?—Yes.

634. Mr. *H. Vivian.*] Practically speaking, has not every colliery in your district a nearly constant quantity of air passing through it?—In those collieries which I have inspected a second time, I have found generally that the volume has been considerably increased; the one-fifth of which I have spoken was a deficiency occurring under occasional circumstances. A large deficiency sometimes occurs from the clinkers on the furnace, or want of skill in the flueman.

635. Is it not largely to the interest of the proprietor of a mine to have his colliery well ventilated?—Undoubtedly; I do not think there is a more important point, with regard to the economical and proper working of a colliery.

636. Are you aware of the expense which falls upon the proprietor of a coal mine, when an accident does occur?—The expense is enormous; it is several thousand pounds in the more serious explosions.

637. Then, is it not immensely to his advantage to do everything in his power to avoid accidents?—To his real and true advantage, I believe it is.

638. Do you conceive that working miners generally know anything of the ventilation of a colliery?—Nothing; they generally object, when there is any increase in the ventilation; but in instances where the ventilation has been largely increased, and they have had considerable experience of its benefits, they have stated that they could do one fourth more work in the course of the day.

639. A working miner is in the habit of going down his pit and straight to his stall?—Yes.

640. He neither turns to the right nor to the left?—No.

641. He is not aware of anything that goes on in the working of an extensive colliery?—No.

642. Consequently, he cannot be at all a judge of the general state of the ventilation in the colliery?—He has only a local knowledge.

643. Would it be possible, by any mechanical means, to measure the distribution of the air in a colliery, the splits being numerous?—You can measure each split separately.

644. Do those splits constantly vary?—According to the requirements of each district, the split is increased or diminished in amount.

645. So that, during your absence, it might be absolutely necessary to cause more air to pass into one portion of the colliery, and less into another portion?—Yes.

646. If by placing anemometers in the various splits, you compelled, to a certain extent, the proprietor of a coal mine to pass a certain quantity of air in certain directions at all times, might not that really endanger the proper distribution of air in the colliery?—Yes; he would be changing it from time to time; if he kept it the same, it might occur that a portion of the colliery had not a sufficiency of air for the safety of the men.

647. Would he not be obliged at all times to explain why he had changed the ventilation of his colliery?—Yes, if that was the regulation.

648. Might that occur from week to week, from day to day, and from hour to hour?—Yes.

649. *Chairman.*] The anemometer being an instrument simply for measuring the velocity of the air?—Yes.

650. Mr. *Cayley.*] With the sectional area of the gallery it shows the amount of air which passes?—If you multiply the velocity by the area of the gallery it gives the cubical amount of air that passes.

651. *Chairman.*] You were understood to state, that if any appliance were made to contract the area, the velocity of the anemometer would be increased, inasmuch as a certain quantity of air would travel through a smaller space at an increased rate?—Yes.

652. Is it not, therefore, always in the power of the overman of the mine to deceive the inspector, if he chooses so to do?—Yes. The velocity which is indicated by the anemometer is to be multiplied by the area of the point at which the anemometer is placed; if this point were contracted by a plank or anything else being alongside of it, and that was removed before the inspector came, the inspector would not know what was the correct area to be employed; and consequently the anemometer would give a very incorrect indication of the quantity of air.

653. Mr. *Stephenson.*] Suppose a bord eight yards wide is being driven, and it is a very foul one, you take the air up to the face of the work by a brattice; is not that the mode of doing it?—Yes.

654. Supposing that you place in the in-gate an anemometer, and ascertain that there is a large quantity of air going up, is not the safety of that bord entirely dependent upon how near the brattice is carried to the face of the work?—The air returns by the shortest course, round the end of the brattice; and if the brattice is not carried sufficiently far on, a body of gas may be left there without its mixing with the air.

655. And the bord would become dangerous?—Yes.

656. Therefore the volume of air going up the bord is no criterion of the safety of that bord, unless the brattice is carried sufficiently near the face to sweep the face of all gas?—No.

657. Therefore it depends rather on the care with which the workmen really carry on the brattice towards the face?—Yes; I consider this distribution of air to be a most important consideration in every fiery colliery.

658. Would the velocity or the volume of the air, without other detailed knowledge, give you any means of judging of the proper distribution of the ventilation of the mine?—No.

659. Mr. *Cayley.*] The extent of the brattice is no test without a proper quantity of air?—The first point to determine is the quantity of air that is required, and next, the proximity to which it must come to the face.

660. Do you think that in every part of a mine there should be a certain minimum amount of air for the safety and health of the miners?—In every fire-damp mine, the minimum quantity of air required for the safety of the mine is different, and it varies in different parts of the same mine.

661. Varying how many feet per second?—From 200 cubic feet per minute to 600 feet per minute, per man.

662. Mr. *Stephenson.*] Does not that depend upon the extent of the workings of the mine?—It ought never to be less than 200 cubic feet per minute, per man, under any circumstances, in a mine containing fire-damp.

663. Mr. *H. Vivian.*] You are now speaking of the air brought to the workmen, and not of the air sweeping the goaves?—I am taking the whole quantity of air which comes into the mine.

664. *Chairman.*] Unless you have a sufficient quantity of ventilation going down the mine, and distributed over all parts of the mine, the ventilation is defective?—Yes; there must be an active current everywhere.

665. You must have a sufficient quantity to fill the whole mine, and to sweep it from danger?—Yes.

666. Mr. *Locke.*] Whatever may be the quantity of air which you may force down a mine and throw out of it, unless it is properly distributed, is it of any use?—No; that is the great point.

667. Mr. *H. Vivian.*] And no instrument can test the distribution of the air?—No one instrument. The water-gauge affords some indication of the distribution.

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668. Mr. *Cayley.*] Would not an anemometer be a test, if placed in the drift, whether the air goes or does not go through it?—Unless you put an anemometer in every working point, you cannot tell that the air is thoroughly distributed.

669. Mr. *Locke.*] Are you of opinion that an anemometer could give a certain indication of the proper distribution of air throughout the entire mine?—One anemometer certainly could not.

670. Keeping in mind the question which has been put to you in reference to the extension of brattices, will you state whether an anemometer, or any number of anemometers, would indicate with certainty that the air had been thoroughly and perfectly distributed throughout the mine?—If you were to place an anemometer at the end of every heading, such as Mr. Stephenson has described, in every place where a man works, and multiply the number, it would give you an indication of the quantity of air that was passing; but it would be no criterion whether that quantity of air would be sufficient to dilute the gas to the extent required by safety.

671. Would it at all times secure the sweeping of the face, so as to make the face where the workman is engaged perfectly safe?—No; I do not think the placing of these anemometers would secure that, and it would be impossible to carry it out in practice.

672. Mr. *Cayley.*] You state that it would be a test of the quantity going into any part of a mine, but not of the purity of the air passing?—Yes; if you take the simple case Mr. Stephenson has put at the end of a heading; if you put it at the extreme end it would tell you the quantity of air that was passing.

673. But not the purity?—No; the proper quantity of air would depend upon the discharge of gas which there might be, from time to time, at the end of that heading.

674. The greater the amount of air which was passing, the greater probability there would be that the deleterious gas would be diluted?—Certainly.

675. *Chairman.*] And always providing that the anemometer is not tampered with?—Yes. I think it is a plan that could not be practically carried out.

676. Mr. *Locke.*] Supposing the anemometer to be placed at the end of the brattice, and a constant supply of air to be passing through that brattice, would not the increase of the working, by every foot the miner went, increase his danger, notwithstanding the quantity of air remained the same?—If the anemometer was close to the end of the brattice, and the brattice was not lengthened as the heading advanced, the danger to the workmen would be increasing, whilst the indications of the instrument remained the same.

677. Mr. *Cayley.*] You have now no test whatever of the amount of air going into a mine?—Not during my absence.

678. When you go there, how do you test its ventilation?—I try the quantity of air passing in each split by an anemometer, and I judge by a candle whether that quantity is sufficiently carried round the mine where the men work.

679. Mr. *H. Vivian.*] You do not find, practically, that they vary from visit to visit?—In almost all cases I have found it considerably increased.

680. *Chairman.*] Will you furnish the Committee with a tabular statement of the number of accidents which have happened in Hainault, and state the number of workmen and the quantity of coal raised, and the average number killed and wounded in 10 years?—Yes. This is a Table of the number of accidents which have occurred in the coal mines in Hainault in 1849, in 1850, in 1851, and 1852. [*The Witness delivered in the same.*]

Vide Appendix.

681. Is the greatest excess of deaths in England, France, or Belgium?—The average is taken in 1851 and 1852 in Great Britain, over 460,000 persons employed; in Belgium, from 1846 to 1850 (as given in the last-published Returns), the number of workmen upon which the average is taken is 256,760; the number of workmen on which the averages are taken in Westphalia is 73,275. The deaths from falls of roofs in Great Britain were 14·4 in 10,000 persons; the average is taken on 10,000 persons employed for one year. In Westphalia there were 10 persons; in Belgium 9·4 persons killed from the above cause. The deaths from explosions of fire-damp in Great Britain, 12·4; in Westphalia, 1; in Belgium, 5·4; accidents in shafts of all kinds in Great Britain, 9·0; Westphalia, 4·0. In Belgium they are divided under breakage of ropes and chains, 3·2—ladders, 0·8; other accidents in shafts, 3·6, making a total of 7·6 from accidents in shafts in Belgium. In Great Britain the miscellaneous accidents

accidents amounted to 6·1; in Westphalia, 1·0; in Belgium, from blastings, 0·6; from inundations, 0·2; miscellaneous, 5·0; the sum total of all being, 41·9 deaths in England; 28·2 in Belgium; and 16·0 in Westphalia, out of 10,000 persons employed one year.

682. Then it appears, by your comparative statement, that the excess of deaths is more in England?—Considerably more in England.

683. Can you account for the cause of the great excess of deaths from explosions, falls of roofs, and other causes, in England?—The difference arises, I think, from the very perfect system of management in Belgium. Mines are, first of all, laid out under the supervision of very competent men; there is a sufficient number of men appointed in the colliery, by the proprietor, to insure its safety; and there are frequent inspections made by the Government engineer, to see that the regulations are carried out.

684. As to falls in shafts, is not the relative proportion very much in favour of Belgium?—They are a great deal more than in Westphalia, and rather more than in Belgium.

685. How do you account for that?—That arises from the use of ladders being compulsory in Belgium, for the men to descend to the shafts; and in many cases, they are obliged to ascend also by the ladders.

686. Do not a great many men fall down shafts in England, from the pits being exposed without any fence round them?—Yes, it is a disgrace to the country.

687. In your opinion, would it be proper to enact a law to prevent pits being left in an exposed state?—I think it is a most important point for legislation.

688. Are there not cages adopted in some parts of England, by which no accident can occur when a pit is at work?—When guides and cages are employed, the accidents in shafts are much fewer.

689. Are there not coverings on the tops of the pits adopted in some parts of England, to prevent men walking into the pit, when the pit is in motion?—Yes; or the top of the pit should be fenced off, with the exception of the place where the coal is taken in or out; and the top of the pit may be entirely protected, without inconvenience.

690. Mr. *H. Vivian.*] Would it not be more destructive to life, if men were compelled to ascend by ladders in this country?—In the deep pits, it would be more injurious.

691. *Chairman.*] You state that mines are better laid out in Belgium, and that the Government inspectors are more efficient and have more power to carry their regulations into effect. Will you describe to the Committee the number of the inspectors, and their power, in Belgium?—There are two mining districts in Belgium; the district of Mons and the district of Liege; an engineer-in-chief resides at each of these districts; and the remaining staff are six engineers of the first and second class, eight sub-engineers, and 30 aspirants.

692. Will you describe the duties of the engineer-in-chief?—The engineer-in-chief receives the reports of the aspirants, investigates all important cases, and communicates directly with the Director-general at Brussels, and with the Minister of Public Works.

693. What are the duties of the Director-general?—He is in constant communication with the Minister of Public Works; and he exercises a surveillance over the whole of the staff, who are dispersed in different parts of the country.

694. Under him are there three inspectors-general?—No, only one, and two engineers-in-chief. The three districts have been lately made into two; one has been suppressed.

695. One of the three engineers has been suppressed?—Yes.

696. How many sub-inspectors are there?—There are six engineers of the first and second class, eight sub-engineers, and 30 aspirants.

697. Were there at any time 40?—That number would probably include another class employed in the public works.

698. Then the number you have given is for the collieries, and all other mines and manufactories?—For mines, quarries, foundries, and stationary steam engines.

699. Will you describe to the Committee the duties of the eight sub-inspectors?—They are sub-engineers. The engineers of the first and second class are under the orders of the engineer-in-chief; he gives them the charge of a portion of a district. The eight sub-engineers are distributed in the same

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way, sometimes having an independent charge under an engineer-in-chief, and sometimes under one of the engineers of the first and second class. The other aspirants are under the direction of those who are in superior offices. The aspirants are those who more particularly inspect the collieries. The sub-engineers are called in, or they come of their own accord, when there is anything very important.

700. Mr. *Fitzroy*.] What are the powers of the aspirants?—The aspirant engineers in their visits direct their attention to that which concerns the conducting of the works, the preservation of the mines, the safety of the workmen, the means of lighting, ventilation, support of the roof, use of gunpowder, protection from water, and the safety of the surface. They verify the plans of the progress of the works; they certify the regular keeping of the registers of progress, and examine into the control of the workmen, their registers, &c. They watch over the execution of the laws of steam engines; they inquire by *procès verbal* into accidents, and all contraventions of the laws and rules; they obtain all the necessary elements for fixing the proportionate dues, and collect all the documents for detailed statistics of mines, quarries, foundries, and steam engines. They assist in drawing up the preliminary information in case of a dispute between the proprietors, in verifying plans of the surface, and demands for concessions of mines, and the plans for establishing or removing foundries.

701. *Chairman*.] Do the mines in Belgium belong to the Government?—By the French law of 1791, modified in 1810, which they have adopted, the mines are the property of the Government.

702. Your account of the duties of the aspirants seems to do away with the use of overlookers; are there overlookers besides?—Yes; in the same proportion as in England. Each aspirant inspects 30 or 40 mines.

703. Have they the power of stopping mines or of giving directions, or what sort of directions have they the power of giving; how far, in point of fact, does their power go, and where does it cease?—There is a very excellent collection of rules for collieries, which are part of the laws of Belgium. Each province had distinct regulations made by its own Council, with the assistance of the engineers; and these were altered into a general law. Before this law was adopted a Council was formed, which was composed partly of colliery managers, and partly of Government engineers, and, having been agreed on by them, it was passed as a law. It is so well drawn up, and the precautions are so plainly stated, and are so applicable to our English mines, that, if you will allow me, I will put it in. [*The Witness delivered in the same.*]

Vide Appendix.

704. Can you state up to what point their power goes, and where it ceases?—They interfere as little as they can with the working of the mine. Their principal duty is to see that these regulations are strictly adhered to. In an extreme case, if they find that a mine is exceedingly dangerous, as they informed me, they have the power to order the men out. I have looked carefully over the laws, and I do not find that very distinctly mentioned. The clause which bears most upon it is this: "When an engineer, in visiting an *exploitation*, shall perceive an imminent cause of danger, he shall give, on his own responsibility, all the necessary directions to the local authorities, in order that it may be provided for on the spot, according to the arrangement which he judges to be convenient; he shall, without delay, inform the prefect of everything." I may explain, that the way in which he is able to order the men out, is because any danger must be a contravention of those rules which are distinctly laid down.

705. Has he the power of stopping the mine?—He can order the men out of the part that is dangerous, at least such is the practical working of the law.

706. If the men are ordered out, is it not virtually stopping the mine?—It is the practical working of the law; I am not prepared to say, that there is anything which will apply more nearly to it than this; but at Mons and at Liege, I was told distinctly that they had the power to order the men out.

707. Are there any penalties leviable on proprietors who refuse or neglect to obey the orders of the aspirants?—If any fatal accident occurs, the proprietor of the mine is fined, and to that is attached imprisonment. The fine for a breach of the regulations is under 8 *l.*, and a week's imprisonment. That applies to the workmen as well as to the masters.

708. Mr. *Stephenson*.] Although the workmen may know nothing of the art of ventilation?—There are rules for the workmen, as well as for the masters.

709. *Chairman*.]

709. *Chairman.*] In point of fact, it is their duty to see that a regular system of regulation is carried out in the mines?—Yes.

710. Independent of those duties, have the aspirants anything to do with the collection of the revenues of the Government?—Yes; a royalty of 2½ per cent. on the profits is paid to the Government; and the aspirants, and the other engineers, have to determine what those dues amount to in each mine.

711. If, therefore, a mine were not properly worked, the aspirant would complain that they were not worked in a satisfactory manner, and that they were not yielding as much profit as they would produce if they were worked in a better way?—He returns the actual profit, as near as he can ascertain it, which the owner has made during the preceding year; and upon that amount 2½ per cent is charged. He cannot prescribe the mode of work.

712. You were understood to state that the mines were better laid out in Belgium than they are in England?—I think they are. With regard to the distribution of air, which is an important point, they form a marked contrast to the mines in England; and although there is not so large a quantity of gas probably in Belgium as there is in England, on the average, and the quantity of air is a good deal less than in some of our well-managed mines, yet the perfect distribution of air, and the thorough discipline and management, prevents so large a proportion of accidents arising from explosions.

713. Comparing the management of mines in Belgium with the management of mines in England, are you prepared to offer any suggestions for the improvement of our system?—I think that the best managed collieries in England are often nearly as well managed as collieries can be managed; but the distribution of air is, I believe, very generally neglected. I know that the opinion of many eminent viewers is, that they should have a current of air of a certain velocity, from three to five lineal feet per second; but I believe there is hardly a mine in the country where that is carried throughout the working faces, as far as my own observation has gone.

714. Are the mines in Belgium as fiery as the mines in England?—The seams in Belgium lie very peculiarly; they are exceedingly steep and turned over several times; the discharges of gas are rather unequal; more gas is found in strata which have been interrupted by faults; and, therefore, in some points, they are more dangerous than the average of the English collieries. And it is possible they may contain a good deal more gas than I was able to see; for the works being, by law, always carried on in a descending direction, the gas filters out from the coal, and immediately passes off. The great principle of the ventilation of mines in Belgium is that of ascensional ventilation, and throughout the Continent the greatest stress in laid on that point. By keeping all the air courses in a mine gradually inclined upwards to the up-cast shaft, even a blower of gas which comes off finds its own way to the surface.

715. Taking the average of the English mines and the average of the Belgian mines, you think the Belgian mines are as dangerous and as fiery as those in England?—I think there is not more gas in the Belgian mines, on an average, as far as I could see; but still it was difficult to form an opinion, in consequence of the coal being worked in such manner, as to get rid of the gas before it was perceptible.

716. Are there any mines in Belgium of as fiery and dangerous a nature as the most fiery mines in England?—The most fiery mines in England are more fiery than any coal mines in France, Belgium or Prussia.

717. According to your experience, do you find that mines are better managed in England, where the danger is greater, or in districts where there is not so much fire-damp to contend with?—Where there is a great deal of fire-damp, they are generally better managed.

718. Taking a comparison between Northumberland and Durham, where the mines are managed on the best principle, do you find they are as well managed in Belgium as they are in England?—I think there are no mines in England which, as regards discipline, surpass the Belgian mines.

719. That is, in police discipline?—Yes. I am speaking not of the control of the Government engineers, but of the discipline of the persons employed by the proprietors of the collieries. I believe it is not surpassed even by the best managed English mines.

720. Can you state with regard to what department of the management of the best regulated English mines in England the discipline is better in Belgium,

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and where you think that improvement could be effected?—The first point is, that each workman in a colliery has what is called a *livret*, which is a register of his character from the day of his birth, and a certificate from each employer he has been with; and without having that book he cannot be employed in a mine. The consequence is, that an engineer knows the character of the men whom he employs in fiery workings. The next point is, that a book is kept at the colliery, in which the names of the men are entered (for the inspection of the engineers), who are responsible for any important duties of the colliery. A number of supervisors are appointed, whose duty is to go through the mine several times during the working hours, inspect the state of the lamps, the conduct of the men, and the state of the mine. If any dangerous circumstances arise they are obliged immediately to report them to the Government engineer, so that in addition to the ordinary manager of the colliery, the highest engineering talent they have is immediately brought to bear in the solution of any difficulty, and introducing more safety by removing the cause of danger in a mine.

721. Do you consider that sub-engineers or aspirants are a superior class of men to the class of men who are called head viewers in the north of England?—The aspirants are the most highly-educated men in Belgium. Only the head student in each year of the first Mathematical College in Belgium is admitted into the mining service. In France it is the same.

722. At what age are they admitted?—Before they can enter the mining school at Liege they are examined in the higher mathematics (spherical trigonometry, geometry of three dimensions, integral and differential calculus), elements of mechanics, and descriptive geometry; they remain at the school three years, and they have to pass five strict examinations before they can become aspirants.

723. Mr. *Stephenson.*] At what age do they enter the school?—They must be at least 18, and remain until they are 21 years of age before they become aspirants. They undergo another examination before they become sub-engineers.

724. Mr. *H. Vivian.*] During the time they are at school, do they visit the collieries in the neighbourhood of Liege?—Yes.

725 Mr. *Locke.*] Have they any official position until they become aspirant engineers?—No.

726. Do they obtain that official position at the age of 21?—That is the minimum age; they are about 23 years of age on the average, when they enter the service.

727. *Chairman.*] Comparing the management of mines in Belgium and France, your opinion is, that even in the best regulated mines in England some improvements might be effected?—I will not go so far as that; I have stated that the best managed mines in England do not surpass the mines in Belgium.

728. In ordinary managed mines in Belgium, the system is infinitely superior to the system in England?—Yes, the superiority is remarkable.

729. Do you attribute that superiority solely to the system of inspection?—I attribute it, primarily, to that admirable code of regulations, which must be admitted by every experienced colliery manager to be very important; and next, to the manner in which the engineers see that those regulation are carried out.

730. Is it your opinion that such a system of laws could be enforced in England?—Not at all to the same extent.

731. You stated, in your evidence in 1852, that there were about 400 collieries in your district, and that you could not visit them more than once in every four or five years?—Yes.

732. What improvements can you suggest in the inspection of mines in this country, not for the purpose of making it as rigid as in Belgium, but in order to make it as effectual as the circumstances of England will allow?—I think there ought to be, in the first place, a certain number of the most important regulations to form the law; because that practically removes the responsibility from the inspector which might otherwise attach, if he had the power to order those things only when he found them deficient. In order to carry out these regulations, I think there might be an increase in the inspection, with very satisfactory results.

733. Mr. *Fitzroy.*] By an increase of inspection, do you mean an increase in the number of inspectors?—I think there ought to be a second class of inspectors; I do not think it is desirable to decrease the extent of the districts, because

because it is very important to have a variety of mines to compare, and to see the application of rules and improvements; and, besides, the system would be better organised; but I think that something of the same system which is adopted in Belgium (and I am not disposed to recommend any particular course) might be adopted with success in this country.

734. *Chairman.*] Do you think the system in Belgium tends in any way to take out of the hands of coalowners the proper responsibility which ought to devolve upon them?—No, quite the contrary.

735. Is it your opinion that any step which would take out of the hands of the coalowner the proper responsibility which should devolve upon him, would be injurious?—Undoubtedly.

736. Mr. *Fitzroy.*] Do you think that even if the powers of the inspectors were not increased, an increase in the number of inspectors would alone tend to promote greater safety in the mine?—I think so.

737. Supposing no alterations were made in the powers of inspectors, do you imagine that the establishment of such a class of men as you propose, subordinate to the inspectors, would tend to increase the safety of the mines?—I have no doubt that an increase in the number of the inspectors would diminish the number of accidents.

738. Even supposing their powers not to be extended?—Yes.

739. *Chairman.*] You stated, in a former part of your evidence, that every suggestion you had made had been willingly carried out by the coal owners and the overlookers?—I said that they generally promised to carry out the suggestions, and that in some instances I had found them carried out.

740. Do you think they would pay the same attention to an inferior class of men as they would pay to the inspector himself?—No; they would not pay so much attention, unless there were a code of regulations.

741. Taking that fact into consideration, do not you think that, instead of having an inferior class of men, subordinate to the present inspectors, it would be better to increase the number of inspectors and to give them higher salaries?—I think that the sub-inspectors might report to the superior inspector in important cases; but it would require a great deal of consideration, the class of men whom it would be safe to intrust with the position of sub-inspectors.

742. Mr. *Fitzroy.*] You are of opinion that it would not be desirable to diminish the area of the district of an inspector?—Yes.

743. That is, on the ground of the variety which exists in the mines, which it is important for him to have under his eye, that he may be enabled to adapt his regulations to each?—Yes; in collieries there are constant improvements going on, and by having large districts he will be able to communicate those improvements from one point to another; and experience gained in this way would be valuable.

744. Do you think it is desirable that the districts should be of such an area as to admit of the visits of an inspector only once in four or five years?—I think that the visits ought to be more frequent than once in four or five years.

745. You have stated that it would be impossible for you to go over your district and inspect each mine in less than three or four years?—Yes; I think the number of inspectors should be increased in some way, after the system which is pursued in Belgium, so as to allow of inspection once a year.

746. You think it is desirable that an inspector should visit each mine in his district once a year?—On an average.

747. The inspector himself?—Yes, or the sub-inspector.

748. Do you think it would be satisfactory, that the inspection of the mines should chiefly rest on the new class of men, whom you propose to establish?—Yes, but it is essential that they should be highly educated men.

749. Do you think it would be sufficient for the public safety, if the inspection was principally made by them, and the reports only made to the inspectors?—Yes, if you had a proper class of men.

750. Are you in a position to propose to the Committee any extension of the powers of the inspectors, at the same time that you propose to establish this new class of men?—I am not prepared to make any proposal of that kind; I think it would be much more satisfactory to have simple regulations which were generally applicable; for by giving increased powers to the inspectors, to some extent, you might remove the responsibility of the proprietors of the mines.

751. Mr. *Locke.*] Would you make those regulations universal, or would you limit

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limit them to particular districts?—They ought to be so simple, as to be generally applicable to collieries.

752. Do you think that a code of regulations could be adopted, which might be applied universally throughout this country?—Yes.

753. Do you think that you could yourself draw up a code of regulations for that purpose, which would include all classes of collieries?—Yes; I think there is no difficulty in it. I should extract some of the printed rules of the Newcastle collieries.

754. Mr. *Cobbett.*] Perhaps you have framed something of the kind?—No.

755. Mr. *Fitzroy.*] Is it your opinion, that the majority of the accidents which now occur arise from the neglect or contravention of regulations which have been laid down for the management of collieries?—There have been no regulations laid down; I do not exactly understand the question.

756. Is it your opinion, that the majority of accidents which now takes place in English collieries, arise from the neglect or disobedience of regulations which have been laid down with respect to their management?—I think that the majority of them occur from the neglect of regulations which are laid down in well-managed collieries as essential for safety.

757. By the proprietors themselves?—Yes, or by the managers.

758. Not by the Government inspectors?—The Government inspectors have laid down no regulations.

759. In what way will the safety of a colliery be increased by the presence of the class of men whom you propose to establish, if they are to lay down no regulations for its management?—There would be the same influence exerted as there is now; when an inspector visits a mine, he will point out the dangers and defects which exist in it; and if an accident occurs, by stating this at the inquest there will be a greater degree of responsibility thrown on the proprietor of the mine, or the persons employed in it.

760. Then the only additional safety to the public would arise from more frequent inspection?—I have recommended a simple code of laws, as well as an increased number of inspectors; it would materially assist the decisions of coroners' juries.

761. Would you propose to delegate to these sub-inspectors the same authority during the time of their inspection as you now yourself enjoy, with regard to pointing out dangers and so on?—Yes.

762. Do you think you would be able to secure the services of a class of men of sufficient engineering and general scientific acquirements to enable them to perform these duties satisfactorily, on the scale of salary which probably you would propose if they were to be subordinate to the present inspectors?—No, I do not think we should.

763. Do you think that the services of men of sufficient acquirements could be obtained upon the terms which would probably be offered to them as sub-inspectors?—I do not think they could be found permanently at the present salary of an inspector; they ought to be a class who would be promoted, and there ought to be always an opportunity of rising; I think that would tend to get their services, and to keep their services when obtained.

764. Do you propose that they should perfect their education in a manner to fit themselves for the duties of inspectors, by the experience which they would obtain in the mines?—Yes, after a thorough scientific education.

765. You do not propose to find men who are already fully acquainted with the working of mines, and of great scientific acquirements, to commence this career?—I do not think you will find them; and I do not think you will be able keep them, if they were appointed. The department must be increased very gradually.

766. Do you think it would be a satisfactory arrangement for the public to take men at a very reduced salary to undertake these duties nominally, but really in order to go through a course of study to fit them for the situation of inspectors afterwards?—I know that no other class of men would be so likely to remain in the service, as men who have been selected in the same way that they select the engineers of mines in Belgium.

767. Do you think it would be a beneficial arrangement for the public?—I think it would be the best arrangement. There would be less danger than in having inspectors of the other class that has been proposed, who would be wanting in tact and gentlemanly conduct.

768. Mr.

768. Mr. *Locke*.] Are the persons who now have the management of collieries in your district intelligent or otherwise?—I think that, on the average, the overmen are not very intelligent.

769. Do you extend that answer to the general managers, as well as to what are called overmen or wastemen?—In my district they are generally overmen. Where there are engineers employed, they are very superior men.

770. Are there any superior men employed in that district as in the north of England; viewers of considerable note?—Yes; there are some viewers employed.

771. But you think that the class of persons who have the daily superintendence of the mines are not persons of a very considerable amount of intelligence?—No; there is a great deficiency of information among the overmen on many important points of safety.

772. Is it your opinion that they are not well calculated to conduct the under ground operations of the mines?—Generally speaking, I think they are wanting in every essential information for that purpose, especially with regard to ventilation.

773. You have stated that you are able to arrange a code of regulations which would be universally applicable to all mines. Would you in that code stipulate any fixed quantity of air for the supply of a mine or not?—No.

774. Would you stipulate for any fixed velocity of air through the mine?—Not further than this: that speaking simply of non-fiery collieries, I think there ought to be artificial means of ventilation, and that the current of air in every part of the mine should be just perceptible by the ordinary test of the candle.

775. Then would your code admit of two or three different classes of mines, namely, those which were fiery and those which were non-fiery?—There would be some rules which would not apply to non-fiery collieries at all, and there would be some rules introduced specially for them.

776. Do not you think there might be a difficulty, in case a jury were inquiring into the cause of death, in ascertaining whether a colliery should be designated fiery, or non-fiery, or moderately fiery?—If a jury were investigating a death by explosion, there would be no doubt in their minds that it was a fiery colliery; and unless they were investigating such a case, they would not go into the matter.

777. Would you consider that every colliery in which an accident might arise of any kind, was really what you would call a fiery colliery, and designate it as such, as distinguished from other collieries which had not much fire in them?—Yes; I can hardly conceive it possible that the presence of fire-damp should not be recognised in a colliery long before any accident occurred from it.

778. In whatever degree, therefore, that air should exist in volume in the mine, you would designate it, and apply your rules and regulations to it, as if it were a fiery mine to any extent?—The rules would be so simple, that they would apply to all mines in which there was fire-damp.

779. Do you think that those simple rules would be entirely efficacious in preventing an accident in any mine?—They would reduce the number of accidents.

780. If rules were laid down with reference to a very fiery mine, would the same rules, in your opinion, be proper rules to apply to a mine which was not so fiery, but was subject to a moderate amount of foul air?—Some of the rules would certainly apply to both. It is difficult to speak generally. In order to make the case more clear, I will take a special case. My own opinion is, after long consideration and inquiry, that the use of locked safety-lamps should be compulsory in every colliery where there is any fire-damp at all; that is an important rule, which, I think, ought to be generally applied.

781. *Chairman*.] Do you mean that the rules which you suggest are so general, that they might be applied to any mine, whether it was fiery or otherwise?—Not having framed the rules, I am not prepared to say there should not be some which would be specially applicable; but there are two or three of that simple kind that they would apply generally. I have given one as regards a non-fiery colliery.

782. Whether a mine is fiery or not fiery, looking at the health of the men, do you think it would, or would not be proper for the Legislature to forbid any colliery being worked at all without artificial appliances?—I think it is most desirable that artificial ventilation should be made compulsory. I believe that

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more injury is caused to life and health by the want of ventilation in non-fiery collieries, than by all the accidents by explosions.

783. Mr. *H. Vivian.*] Are there any collieries in your district which are ventilated by natural ventilation, with a sufficient current of air passing through them?—In the depth of winter, in many well laid out collieries, where there was no fire-damp, you could have a sufficient current of air by natural ventilation. I am giving you the most favourable circumstances. In an extreme case, you may get a sufficient current of air by natural ventilation.

784. Mr. *Locke.*] You have stated, that you think a better mode of distributing air in a mine is pursued in Belgium than in England. Will you explain to the Committee the difference which you have observed between the mode which is adopted for distributing air in mines in Belgium, as compared with that which you have seen in this country?—By law, in Belgium, when the air has once descended into the mine, it must always ascend; the air must never re-descend without the express permission of the Government engineer; a permission which is very seldom granted. The next point is, that the gobbing, as will be seen by those laws which I have put in, is very carefully attended to; the whole space between the air-ways is filled up, and it has, by law, to be carried on to within a very short distance of the face, so that the air is carried along the bottom level, until it reaches the working face; it passes right up the working face; it is kept close to it by the gob, and the gas which escapes is swept off along the return air-ways, without obstruction to make it accumulate.

785. Can you state the distance to which they are obliged to carry the gob to the face, by the Belgian regulations?—The distance is not specifically mentioned; it varies in different seams, but it is generally carried from four to ten feet from the face.

786. There is no regulation as to the distance to which it shall be carried?—No.

787. Mr. *H. Vivian.*] Can you state the thickness of the largest seam of coal in Belgium, where that rule applies?—About four feet.

788. Mr. *Locke.*] Are there not thicker seams of coal than four feet in Belgium?—No; I think that is the thickest seam.

789. Mr. *H. Vivian.*] Do you conceive that such a principle can be carried out in larger seams of coal?—The same principle; that is, filling the stopping well up is applicable everywhere.

790. But not the gob?—They work in long work in Belgium.

791. You work with stall and pillar?—Yes; and the stoppings are generally very much neglected.

792. Mr. *Locke.*] Are the mines in England generally inclined or flat?—Generally flat, some are highly inclined.

793. Would the principle which you say is so beneficial be appliable to a mine which is less inclined, or to a mine which lies flat?—The ascensional ventilation cannot be carried out in some of the English mines throughout; there is one point in flat-lying seams, where the air would have to descend if the up-cast shaft is not altogether to the rise, but it is a dangerous practice.

794. Then you have contemplated cases, where in England it would be impossible to carry out that principle which is adopted in Belgium?—I think the safety could be attained with great care, and the arrangement of the air courses.

795. Then it would not be one of your regulations which you would propose similar to that which is now adopted in Belgium?—No; I should not make it so exclusive a law as in Belgium.

796. Then that advantage which you say you have observed in Belgium, is not one of the advantages which you think would be universally applicable in this country?—No; I should not think it would be as universally applicable in this country as it is in Belgium.

797. Are you prepared to state to the Committee, from your knowledge of the management of mines in your district, that one cause of defective ventilation is a defective distribution of air?—Yes; it is one of the most common causes. To be set in comparison with the gobbing which is made use of in Belgium (carrying the air to the face), I should mention that there is, generally speaking, in English collieries an enormous leakage. A quantity of air comes down the shaft which does not penetrate to the working face.

798. Mr. *H. Vivian.*] Through stoppings?—Yes, besides doors and brattices.

799. Mr.

799. Mr. *Locke.*] What is the distance between the gob and the face of the workings which is usually adopted in long wall work in the districts which you superintend?—The gob walls are not ordinarily sufficient to carry the air sufficiently along the face of work. I have frequently found neglect in that point.

800. Can you state, in feet or yards, of what that neglect consists?—I find it is very commonly the rule, under those circumstances, not to carry forward the gob, or the brattice, as the case may be, until there is some indication of fire-damp in the lamp.

801. Then you think that until they see danger they do not make themselves secure?—Until there is 3 ½ per cent. of fire-damp in the air of the mine, they do not adopt the precaution of carrying forward the gob walls.

802. Mr. *H. Vivian.*] Do you consider the system of gobbing applicable to a larger vein than a four feet vein?—In thick veins you would build gob walls to carry your air forward.

803. I assume gobbing to apply to long wall work?—Yes.

804. You may define a gob as that which is mechanically done?—Yes.

805. While a goaf falls entirely?—Yes.

806. The gob will apply altogether to long wall work?—Not altogether.

807. Is long wall work applicable to a larger vein than a four feet vein?—Yes.

808. Is it applicable to a five feet vein?—It is more favourable in thin seams; but you may work a very thick seam by it, under favourable circumstances.

809. Must it not also depend, in a great measure, on the roof?—Somewhat.

810. If the roof will not fall readily, you can scarcely work long wall work?—It is more difficult. You may have a modification of long wall work.

811. You must work the coal first by stall and pillar, and then by long wall work?—Yes; that is a convenient way. There are two great divisions in long wall working, namely, working from the shaft and to the shaft. When you cannot work from the shaft you can almost invariably work to the shaft.

812. Is it not the fact, that it would be impossible to stow large veins?—It is sometimes impossible.

813. Those veins you would work by stall and pillar work?—No; I think in all veins you could build gob walls of some kind. I can imagine a case where you would have to leave a pillar of coal in order to carry the air in.

814. *Chairman.*] Would you recommend the Legislature of this country to enforce either the system of long wall work or stall and pillar work?—No.

815. If that were done in Belgium it would be because the Government, having a certain per-centage on the profits of the mine, might think it a more advantageous mode of working, and therefore they would themselves, in order to secure their own profits, recommend it; but in England, the system being different, each proprietor working a mine must be left to work his mine according to the system which he deems most profitable?—It would be impossible to say that a proprietor should work his coal in this or that manner. In Belgium it is not done.

816. Mr. *Locke.*] Are you prepared to recommend gobbing on any fixed rule to be carried on?—I should recommend that the stoppings, and everything which conducts the air to the face of work, should be made perfectly tight, so as to carry a sufficient quantity of air into the working faces.

817. Would you be prepared to say that the gobbing should be carried up to within a certain distance of the face?—No; I should not be prepared to say that; I should not recommend the adoption of gobbing as one of my rules at all.

818. With reference to the improved distribution of air, which you state exists in Belgium, are you prepared by any rule to enforce that system in England?—I should not concern myself at all with the air that came down the shaft; if there was any regulation, it should be that a certain rate of current, which I explained by saying it would indicate on the flame of the candle, should be maintained in the working parts of a colliery where there was no fire-damp at all.

819. Can you measure the velocity in feet?—It is 30 lineal feet per minute, half a foot per second.

820. Ought the velocity to be increased according to the amount of foul air which was met with in a mine?—Yes.

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821. That of course would render it very difficult to lay down any general rule, which would be applicable universally throughout this country, where there are so many different classes of mines?—I think you may arrive at a rule in a very simple way, namely, to say that there shall be a sufficient quantity of air to prevent any indication of fire-damp on a safety-lamp.

822. You do not mean to measure it by any fixed quantity, but that there shall always be a sufficient quantity of air to prevent fire-damp being shown either by a naked candle or by a lamp?—By the most delicate tests that we have, that fire-damp shall never be visible in the working face.

823. Whatever quantity of air might be necessary for that purpose, without fixing it in your rule, you would render it imperative upon any person who owned a mine to have that quantity supplied?—I am not prepared to say that.

824. I want to ascertain if we can get into some fixed regulation?—There is no doubt they ought to have that quantity.

825. Then, if they ought to have it, are you prepared to recommend this Committee to enforce it?—There are some peculiar circumstances in which it might be impossible to have that quantity; and there might be some exceptions, such as are provided for in Belgium, where the engineer may allow the air to descend. I cannot give a decided answer off-hand.

826. Then, in point of fact, you would not recommend a system of rules without making exceptions to them?—There might be an exception. It requires consideration.

827. Mr. *Stephenson.*] With regard to inspection, are there not a great number of circumstances almost daily occurring in an extensive colliery, which alter the relation between the supply of air and the demand for it, supposing the demand to be regulated by the principle you now lay down, that the safety-lamp is not to show more than a given indication of gas at the face of the working?—I think, that as a rule, there ought never to be the slightest indication of gas in the face of the work.

828. Are there not every day, in an extensive mine, various casualties which involve a great disparity between the supply of and the demand for air?—A variation to the amount, as I have explained, of one-fifth or one-sixth.

829. It is in evidence before all the Committees which have sat on this subject, that the discharge of fire-damp from coal is exceedingly irregular, and can only be detected by the men who are constantly in the pit, and that occurs almost every day. In order to make the mine safe at different times of the same day, do you not want a different supply of air to keep the ventilation in a good state?—Yes.

830. With such an inspection as you give to collieries, on your visits once in two or three years, what kind of regulation could you apply?—There is a point which it is necessary for me to explain in order to answer that question; that is, to point out that when you begin to see a halo, or indication of fire-damp on the flame of a naked light, there is already 3½ per cent. of gas, according to Sir Humfrey Davy's experiments, and that when there is seven per cent. the gas explodes. That 3½ per cent. under the most favourable circumstances, such as when a man is engaged in examining it, and it is almost pure carburetted hydrogen, is a very small margin indeed to interpose between safety and explosion; and every manager who wishes to put his colliery into a proper state, ought to increase that margin by doubling the amount of ventilation. If I was managing a colliery, upon seeing such an indication, I should double the amount of ventilation, so that I should make the chance of seeing any indication of fire-damp from a blower, or extra discharge of fire-damp, exceedingly improbable. With the safety-lamp the margin is only 2 per cent.; the true cause of the numerous explosions.

831. That is the act of the manager of the mine at the moment when he sees the casualty occurring?—No; he ought to have his colliery worked with so large a margin of safety, that even supposing there was a considerable alteration in the discharge of gas, it should give no visible indication by the rough test we now have.

832. Do you think an occasional inspection by yourself, or any other Government inspection, once a year, or once in two or three years, would meet a casualty of the kind I have alluded to?—No; and that is the reason why I think that simple rules of that sort would materially assist the inspection.

833. Does not the safety of a large colliery essentially depend upon the vigilance

vigilance of the manager?—A good deal; but still if such regulations were enforced, many collieries, which I am not perhaps able to visit, would pay attention to so distinct a law, and it would everywhere have a constant degree of operation, even although I was not able to visit the colliery more than once in several years.

834. Supposing the quantity of gas was never to be allowed to exceed 3½ per cent., when it does exceed it, how are you to know whether a manager has really taken those pains which are necessary for diluting it, or keeping it at that amount of dilution. If he neglects it, supposing that the quantity of gas is very large, and is liberated in one day, scarcely any power he could bring into play would maintain that dilution; how could you blame that man?—I should be able to get a good deal of evidence from the colliers, as to the indications of gas which they had previously seen; and besides this, to guard against any idea that the colliery might be rendered insecure, I think it is indispensable there should be a locked safety-lamp.

835. I want to ascertain how the occaional inspection of mines would essentially operate to reduce the number of accidents?—As I have stated before, the collieries are worked at present in a very dangerous manner; they are worked generally so as just to see the halo on the flame. I think that the quantity of air in those collieries should be doubled, and then it could very seldom occur that so extensive a blower would come off as to make the halo visible.

836. Do not you think that, before a man is allowed to undertake the management of a coal mine, he should be called upon to undergo an examination which should really test his ability?—I think it is a matter of great importance that the manager should go through an examination of that kind, if it were only a simple one, in order that he should know the principles of ventilation, of which many of them in my district are ignorant; but still, from what I have stated before of the improvements which are often carried out on the recommendations which I made to the managers, I think that inspection does and must do much good.

837. I am not disposed to question the utility altogether of inspection; but I rather put that question to ascertain your opinion as to the mode of investigation into the qualifications of the party to whose management a mine is submitted. Would not that be a more direct mode of remedying the evil we are now considering, or would it not be a very admirable auxiliary?—I do not think it would be possible to do it universally.

838. Mr. *Cayley*.] You think that inspectors may suddenly visit a mine, and keep the manager of the mine in proper order?—Yes. I would much rather you would take evidence as to what inspection has done; I think there are engineers coming who can tell you whether an amendment in ventilation and other things in collieries has taken place.

839. Do you think that no mine should be worked in which it would not be ordinarily safe to introduce a naked light?—I think that any mine can be worked, however great the discharge of fire-damp; for I am perfectly sure that, with the ventilating powers we possess, it could be adequately ventilated.

840. You think that however fiery a mine is, there exists a possibility of a sufficient ventilating power?—Undoubtedly.

841. The recommendations that you have given seem to imply rather the means of knowing how an accident has happened after it has happened, than the means of prevention before it takes place: is not that so?—No. In working a colliery you must have some test of the amount of discharge of fire-damp.

842. You have stated that a certain amount of ventilation is necessary?—I only spoke of where there is no fire-damp at all. I think that the air should be in motion in every working part of a colliery.

843. And you are not willing to give any particular amount?—Not less than 30 lineal feet per minute.

844. That is only half a foot per second?—Yes; where there is no fire-damp.

845. Are there many mines in which there is no fire-damp?—I should think two thirds of the mines in my own district have no fire-damp in them.

846. But where there is an average amount of fire-damp, what is the current which you would recommend?—Where there is any fire-damp there should never be less than 200 cubic feet, per man, per minute.

847. What rate of current would produce that in an ordinary sized mine?—Supposing you had 300 men, that would be 60,000 cubic feet per minute.

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848. What rate of current?—Where there is a tendency to fire-damp in a working face, the current of air ought to be travelling at something like three lineal feet in a second.

849. Would you not, in all such cases, establish a minimum, which should be essential to safety?—That is a very difficult point to determine. I should mention, that taking it roughly at so much per man, is not an accurate measure of the quantity of air which is wanted in a colliery. It is a unit of measure which is most generally applicable, and accordingly I put in that form, making the quantity of air depend on the number of men.

850. What should be the supply, per minute, to each man?—There should be from 200 to 600 cubic feet, per man, per minute, or even more than that.

851. Could you not establish that test?—I think it would be exceedingly difficult to define what the limit is, consistent with safety in a colliery, where there is very little fire-damp.

852. I want to ascertain something a little more definite than that it is a test of danger, when the flame begins to lengthen, which appears to me to be the result of the answers you have given in the latter part of your examination?—If in a working face you find a slight indication on the flame of the lamp.

853. Who finds?—The manager of the colliery.

854. The manager is not there?—The fireman informs the manager; the manager is the person to decide what quantity of air ought to go through the colliery. The manager will measure the quantity of air which is then going through the colliery, and he ought to have, at least, double that quantity of air.

855. If he could double that quantity of air, would the air be sufficiently foul to lengthen the flame?—I take the quantity of air at which I just see the halo, and I think the quantity ought to be doubled.

856. When the state of the atmosphere is such as to produce only that halo, you think that the quantity of the air should be doubled?—Yes; to interpose a sufficiently wide margin, in the same way that you make a boiler three times as strong as to resist the pressure which it has ordinarily to bear.

857. Do you think that amount would be sufficient in case of any sudden outburst of gas?—Outbursts of gas might occur which would overcome that in some cases. But such large discharges hardly ever occur in any mine.

858. Supposing there was a mine where these occasional outbursts did take place, would you recommend an additional amount of air?—Wherever a mine is subject to occasional outbursts of gas there ought to be a much larger ratio of air than where the discharge is perfectly uniform.

859. What would be the amount that you would recommend?—Somewhere between 200 and 600 cubic feet per man, per minute.

860. The test you had arrived at was, that when there was a halo round the flame you would recommend double the amount of air to the atmosphere producing it?—Yes; even this halo is often disregarded, or submitted only to the roughest observations.

861. Supposing it is a mine which is liable to these explosions, would you treble or quadruple the amount of air?—That would depend upon the amount of discharged gas. I have given in all cases a minimum in my evidence.

862. In case of an explosion taking place, have you any means of ascertaining the cause of the explosion?—Supposing that such a rule, as it is imagined I might recommend, was carried out, it would be more difficult to say that the overman or the manager was to blame where a colliery was subject to occasional discharges.

863. You would endeavour to get information at the coroner's inquest of what had been the amount of ventilation?—Yes.

864. How would you propose to obtain that knowledge?—I should inquire from the colliers, and firemen more particularly, how often they had seen a halo on their lamps, and in what parts of the mine, and what was about the amount of discharge of gas which had taken place.

865. Is not the fireman generally the offending party?—There are several firemen; I understand you to ask how I should ascertain how far the manager was to blame. We are speaking now of the quantity of air which is going through the colliery, and the manager is the judge of that, in the first instance. If he has not sent a sufficient quantity through the mine, and an explosion happens,

happens, I take evidence as to whether he has done his duty or not, from the firemen or from the colliers, and any other information I can obtain.

866. You have no means of obtaining information or of testing the mine except from the very parties who appear to have neglected their duty?—An explosion could not occur in a mine where all parties were to blame, because their duties are divided in different parts of the mine; and, besides, the collier is not responsible for the amount of air.

867. You have stated, with regard to the anemometer (as is perfectly well known), that where you are lengthening the workings you must extend the brattice, and so alter the place of the anemometer; so that the anemometer must be movable. In your opinion, would not a self-registering anemometer, at the bottom of the down-cast and at the bottom of the up-cast, be a test of the amount of air entering the mine?—It would measure the velocity of the air which passed it.

868. And that, multiplied by the area, would give the amount?—It would then measure the quantity of air which passed.

869. Although a self-registering anemometer at the bottom of the up-cast and at the bottom of the down-cast would be no test of distribution, yet it would be a test of the amount of air entering the mine to be distributed?—Yes, provided it was not tampered with.

870. Would it be so likely to be tampered with, or tampered with in the same way as has been suggested, at the bottom of the down-cast or at the bottom of the up-cast, as it would be in the galleries?—Yes; I do not think there would be more difficulty in tampering with it there.

871. Do you think it would be no additional means of testing the ventilation during your absence?—I should be very glad if such a thing were practicable; but I do not think you would get the managers of collieries to adopt it, or get such a machine to work a month without cleaning.

872. All the other means that you have suggested appear to be very much on the principle of locking the stable door after the horse is gone?—I lock the safety-lamp before the explosion happens.

873. *Chairman.*] You have stated, in one part of your evidence, that there are cases in which you would enforce the compulsory use of the safety-lamp?—Yes.

874. You have stated, with regard to inspectors, that the only mode you have of improving the inspection of mines, would be to appoint an inferior class of men, to be called sub-inspectors?—Yes, but to be promoted as vacancies occur.

875. You can suggest no other mode of improving the system of inspection in this country?—It ought to be combined with a code of regulations, which they should see enforced.

876. You stated that you could frame such a code of regulations; can you, by the next sitting of the Committee, prepare a code of regulations which you think would be applicable to the case, and submit them to the Committee?—I can easily give you the heads.

877. Perhaps you will be kind enough to do so?—Yes.

878. You have heard Mr. Dickinson's evidence as to the mode of ventilation which is adopted in Belgium?—Yes.

879. Is there any part of Mr. Dickinson's evidence with which you disagree?—I do not agree with him as regards mechanical ventilation; I do not think he has seen the results of the experiments. Comparing the effective work with the consumption of coal, it will bear comparison with the best furnace ventilation in the north of England.

Martis, 21° *die Junii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Cayley.
Mr. Stephenson.	Mr. Cobbett.
Mr. Fitzroy.	Mr. Farrer.
Mr. Baird.	Mr. Henry Austin Bruce.
Mr. Locke.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Herbert Francis Mackworth, Esq., called in; and further Examined.

H. F. Mackworth, Esq.
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880. Mr. *H. A. Bruce.*] IN your former examination, at Question 517, you are asked by Mr. Cayley, "You have alluded to the loss of life from explosion, in the Middle Dyffryn Colliery; was that the Aberdare case?—Yes." Then the next question is, "Since 1845, how many deaths have occurred from explosions in that mine?—I think about 165." Upon reconsideration, do you believe that to be inaccurate?—I intended to say 65 deaths from the last explosion in Middle Dyffryn Colliery; there was a previous explosion, which occurred before I had charge of the district.

881. Do you know how many were killed by that explosion?—Thirteen.

882. *Chairman.*] To what did that number, 165, refer?—I intended it to be 65; it is put down 165 by mistake.

883. Mr. *H. A. Bruce.*] With respect to that accident at the Middle Dyffryn Colliery, in your former examination, at Question 573, you were asked, "Do you believe this accident occurred in consequence of those recommendations not being attended to?" that is, the recommendations of Mr. Blackwell; and your answer is, "If his recommendations had been attended to in respect of the brattice, the accident would have been attended with a comparatively small loss of life?" Are we to gather from your evidence that you attribute the accident to the gas having come in contact with the furnace?—Yes.

884. That being the case, the whole question resolves itself into this: whether the furnace was or was not to be considered a naked light?—Yes; I have given that as my opinion, but I have stated that there is a difference of opinion among mining engineers.

885. Did Mr. Blackwell, in his report, call special attention to the furnace, apart from the naked lights?—No, he did not; the furnace was not in at the time the previous accident occurred.

886. How was it ventilated?—It was ventilated by a lamp.

887. Mr. *Stephenson.*] A large coal lamp?—Yes.

888. Which was, in fact, a furnace, not of a large character?—Of the same kind; it produced ventilation in the same way, but was indisputably a naked light. I think I ought to mention that the opinion of the overman of the colliery is, that the gas was exploded by a workman entering a part of the mine where the gas was passing with a naked light, which would be clearly a violation of Mr. Blackwell's recommendation, and that of the jury in December 1850.

Joseph Dickinson, Esq., called in; and further Examined.

J. Dickinson, Esq.

889. *Chairman.*] WERE you present in the Committee-room when Mr. Mackworth gave his evidence on Friday last relative to the inspection in Belgium?—I was.

890. Were you also present when he stated what measures he thought ought to be adopted to make the inspection of England perfect?—I was.

891. Do you agree with that statement? Mr. Mackworth stated that he did not wish to increase the number of inspectors, but that he wished to have a number of sub-inspectors to act under the inspectors, who should be men of some scientific acquirements as well as practical knowledge; and they should be distributed over England; that there should be a sufficient number, so that they could periodically visit the mines and report to the inspectors. Do you think that would be a proper way of improving the inspection which now exists?—I agree with Mr. Mackworth that the appointment of sub-inspectors would relieve the inspector of the most laborious part of his duties, but I think that the appointment of sub-inspectors would be very strongly opposed by the colliery owners, especially in my district, where they have expressed themselves to me as being very much opposed to such appointments. I could give you the names of some of the largest proprietors in Lancashire: Messrs. Knowles are probably the largest colliery proprietors in England. They raise about 2,400 tons per day at the whole of their collieries. They are decidedly opposed to the appointment of any class of men lower than the present standing of inspectors.

892. Did they state their reasons why they object to these sub-inspectors?—They have different reasons; one of which is, that if a lower class of men were appointed, rising engineers, who wished to obtain a knowledge of the district, might accept the appointments, and merely hold them for a time until they became possessed of a knowledge of the collieries and the neighbourhood, and then might retire into private practice as mining engineers; that was one objection.

893. Did those gentlemen at the same time complain of the insufficiency of the present inspection?—No, I have not heard any such complaints.

894. From this evidence in 1852, it is notorious that the present number of inspectors are too little; you stated, as well as Mr. Mackworth, that each inspector had about 400 collieries under his own superintendence, and that it was impossible to go round and visit those more than once in four or five years; now, if you think that appointing sub-inspectors is not the proper way of improving this inspection, what plan would you suggest in order to make the present mode of inspection perfect?—I think, if I recollect rightly, I qualified that recommendation in 1852, by stating, that if it was intended that each of the collieries should be inspected, a very considerable increase in the numbers of the inspectors was imperatively necessary; to make a thorough inspection of all the collieries in this country, such as would be adequate to insure a sufficient control over the management of them, would require a corps as large as the present staff of colliery managers. Even at the present time, under the present arrangements, the manager of the largest colliery in my district, Mr. Peace, of the Haigh colliery, belonging to the Earl of Crawford and Balcarres, publicly stated at an inquest, that his duties as manager of that colliery were so numerous that into some of the pits, where there was not imminent danger, he was only enabled to visit such pits once a year. If the manager of a large colliery can only visit the pits where he thinks there is not imminent danger once a year, it would require a force of inspectors quite as large as the present colliery managers, which I apprehend will never be appointed. I may state that the working of the Act appears to me to have a moral effect, as well as a coercive effect; that improvement introduced into one colliery, at the suggestion of an inspector, is not the less likely to be introduced into a neighbouring colliery, if done apparently at the instigation of the manager of the colliery.

895. Do we gather from your answer that you consider that the present number of inspectors is sufficient?—I think a very moderate increase in the present number would be quite sufficient for all the requirements of this country. If the colliery managers were held responsible for the management of their collieries, and if certain fundamental rules, such as I have stated in answer to Question 744, were laid down for the management of collieries, and an accident happening when those rules have been neglected, if punishment were awarded in those cases, I think that the present staff, or a very small addition to it, would be quite sufficient to carry out what is required.

896. Then you think that, instead of increasing the number of inspectors, that the better plan would be to increase their power?—I do.

897. Will you state in what respect you think their power ought to be

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increased. In your evidence of 1852 you say in some cases the powers are deficient, and you have not the power of suspending operations; you can refer to your own evidence on that point in Question 1848 in the year 1852?—In my evidence of Monday last I have given a list of rules and regulations which, I think, might be laid down as fundamental rules for the management of every colliery in the country. In addition to these there are one or two points in which I think the present Act for the inspection of coal mines might be amended. The first point is, that I think iron-stone mines should be included in the Act. They are very intimately connected with the coal mines; so much so that the air which is used for the ventilation of the colliery is sometimes used for the ventilation of the iron mine.

898. But suppose iron mines were included in the Act, would not that increase the duties of the inspector and give him greater labour?—It would.

899. Would not that be a reason why more inspectors should be appointed?—I think if these rules, which I have named, were laid down, that a very small addition to the number of the inspectors would be all that would be required.

900. Can you state what would be sufficient to embrace a proper inspection, and to include iron mines?—I am not prepared, without consideration, to make such a statement.

901. What is the next thing you would suggest?—Where great danger evidently exists, and the proprietor refuses to resort to the most approved means of increasing its safety, I think the inspector should have the power to order the working of the mine to cease, until such time as its condition be improved, or an arbitration shall have been held on the case; one of the arbitrators to be the inspector himself, and the other to be appointed by the colliery owner; an umpire to be appointed in the usual way, or, failing to agree, an umpire to be appointed by the Secretary of State. I should enforce that by a penalty of 10*l.* per day, or not exceeding 20*l.*

902. Of course, giving the colliery proprietor reasonable time to effect those improvements before these penalties were to come into force?—In the imminent cases; I am speaking now of a case where imminent danger exists, such as the mine being carried on in an explosive state throughout, where the men ought to be ordered at once out of the mine. Such cases are very rare, and in the whole course of my inspection I think I have only met with three cases which I considered imminent; in two of them I succeeded in stopping the mine merely by my representations; in the other case the proprietor went on, and said he would risk it.

903. Not materially increasing the number of inspectors, each inspector having such number of collieries to look after as he at present has, such cases might exist in a great many collieries, and be in existence for a very considerable time before the inspector could find it out; is that not so?—They might; we use the best endeavours we can to get information of such cases, and when we obtain it we at once direct our attention to it.

904. What means have you of procuring this information?—I get such information from a variety of sources, which I should prefer not particularising.

905. Do the men ever give you information, or persons appointed by the workmen?—Very seldom. I rather object to receiving information from the workmen direct, as it might interfere with the good feeling which should exist between master and man; I generally prefer having it through their representative.

906. The question applied to their representative, or anybody appointed by them?—I have from their representatives received information of one or two very bad cases, in that way.

907. And then you immediately go and visit the mine?—I do.

908. Having visited the mine on their representations, have you generally found their representations to be correct or not?—In some cases they were, and in some other cases they were not.

909. Mr. *Baird.*] In the event of the men being turned out of the mine, in a mine of imminent danger, have you considered how the men are to get employed afterwards during that time?—In a large concern you have no difficulty in transferring a few men from one pit to another; considering the great number of pits you have yourself at work you would find no difficulty.

910. Suppose there is only one pit?—I will give a case, where a short time ago, I was enabled to stop the mine. It was a colliery close to Manchester.

On

On visiting it, I found the shaft in a very bad state; there were loose stones and loose bricks almost the whole way down it. I pointed this out to the underlooker who went down with me, and I asked if he was not afraid to go down such a shaft; he said no, he was not. On coming out, I informed the proprietor what I had seen; I said it was not fit to send a dog down. He said, "What must I do?" I said, "I should recommend your stopping the pit at once, and walling it throughout, and putting in guides." "But," he said, "they are working now night and day; the only time we can have for repairing is the hour at dinner time, and during that time the underlooker goes down to fettle it." I said, "That will do nothing, for the shaft is in such a radically bad state, that it requires a thorough repair." He said, "I cannot, without consulting my partners." I said, "I do not wish to press you beyond what you have the power to do. I will give you till Saturday to consider what you will do; and if you do not by that time determine to have it thoroughly repaired, I shall serve you with formal notice in the matter." On Saturday morning I received a letter from him, informing me that, on considering the matter over with his partners, they had determined to stop the pit and repair it thoroughly. What they would do with the men I cannot tell; they had another pit, and probably they would put them into that. At all events, a dangerous circumstance like that would not justify the pit being carried on, although they had no place to put the men.

911. *Chairman.*] Provided they had no place to put the men in, do you think it would be better to order them out, although they might lose a day or two's wages, than to run the risk of sacrificing their lives with the pit in a dangerous state?—No doubt it would; indeed, with proper care no pit should get into such a state. If the pit I have alluded to had been properly repaired, as it ought to have been long before I visited it, it would never have gone into such a dilapidated state.

912. State what other powers you require that the inspectors should have given to them, to enable them satisfactorily to perform the duties that they are called on to perform?—I should ask for no extra powers excepting what I have named.

913. That is, the power to stop the pit?—Yes, and under the reservation which I have named. But with respect to plans, the Act should be more stringent than it is at present. The inspector has the power to order proper plans to be made when he finds them wanting; but I have met with cases in my district where plans have been entirely wanting, and on pointing this out to the proprietor he has undertaken to get them made, which was all the assurance the inspector could demand. But on going back to these collieries about a year after, I have found that plans have not been made, although there was an undertaking that they should be. I stated that we had the power to order plans to be made; but I apprehend that if the inspector ordered plans to be made, he would be responsible for the payment of the bill for them, in the event of the owner of the colliery failing to pay for them. The plans are not, in many cases, kept up in accordance with the Act, therefore, I think that the penalty should attach in every case where the plans are found not kept in accordance with the Act, and that no time should be afterwards allowed to the colliery owners to get the plans made. After the passing of the Act, I should allow six months for proper plans to made in all cases, and after that time I should enforce a penalty of 1*l.* per day in every case where they were not found to be in accordance with the Act, until such time as they were made so.

914. Have you not the power to demand the inspection of the plans?—Yes, we have that power under the present Act.

915. Do you often do so?—Yes.

916. In what character of collieries do you find the plans are wanting?—There was one of the largest collieries in North Staffordshire, belonging to Mr. Sparrow, a very large iron master; he had no plan of it. In another case, in Lancashire, only very recently, I found one proprietor of mountain mines, some small outlying mines, where there were no plans of 11 collieries. In another case, in the Bristol field, when I had the charge of that district, I found several cases about Bristol where there were no plans; they all undertook to get plans made, but, about 16 months afterwards, it was proved that one of them had

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done nothing whatever in the matter, and he had holed into some old working and drowned some men, in consequence of the absence of plans.

917. There being a large stock of water in those old workings which they were not aware of?—They might or not be aware of it; Mr. Mackworth was the inspector for the district when the accident happened.

918. There was a large stock of water there which they struck without taking proper precaution, and by so doing a number of lives were sacrificed?—Yes. In the whole of the Cheadle district, also, in North Staffordshire, I think I only found one colliery where there were plans.

919. Are those large or small collieries?—They were small collieries, but large tracks of coal had been worked away; and there was no record at all of the old workings. I was informed that three of the lessors had plans of their own property, but they formed a very small portion of the district.

920. Mr. *R. Stephenson.*] Generally speaking, you found plans wanting in smaller collieries; did you find them more frequently wanting in small than large?—More frequently in small out-lying collieries. There is a large colliery in North Wales, the Coed Talon and Leeswood Colliery, where I found the plan of one seam was wanting, and the manager undertook to get a proper plan made; but on re-visiting the colliery about a year afterwards, I found he had done nothing whatever in the matter.

921. *Chairman.*] Then we are to take your answer as being that you find in your districts that there is such a deficiency of plans as would suggest to you that an Act of Parliament should be passed, requiring plans in all cases to be made of collieries, and to be enforced by penalties?—That is my opinion.

922. Or immediate stoppage?—Any adequate penalty.

923. Suppose you went into a large colliery where a very large number of men were employed, and you found no plans made of that colliery; if you were at once to order the plans to be made, it would take three or four months to complete these plans in a satisfactory manner; would you on that have ordered the colliery to be stopped?—No. I think the penalty of 1 *l.* per day till the Act was complied with would be quite sufficient; but some provision ought to be made to meet cases where the colliery was nearly done, when it might suit the purpose of the colliery proprietor better to pay the penalty than to be at the expense of making plans.

924. But that would not obviate such an accident as you have just described to the Committee, as to the stock of water, if no plan existed, and that stock remained in the colliery; by proceeding, and making the plans at once, they could not get at this stock of water to see where it was, and they might not be aware of its being in existence; therefore these plans would only show the exact state of the workings which were open to view?—I think the colliery owners had the knowledge of these workings; but as Mr. Mackworth was the inspector for the district at the time of the accident, he will be able to give you details. Admitting that they could not have got any plan of these old workings, to go on without plans is only perpetuating the mischief; and as colliery workings become more extensive, you will have an increase in the number of accidents by inundation, and perhaps by explosion of fiedamp or suffocation, consequent upon holing into old workings.

925. Now, in this case that you have described to us, were the owners of the colliery or overmen not aware that water was in some part of the mine?—I believe they were.

926. Are there not some means of preventing such accidents as these independent of plans; for instance, is it not possible to keep what they call boring rods at a certain distance before them, so keeping pillars between the water and the working; so that if ordinary care is taken the water never could break into the mine and drown the men?—If you have not got plans, boring is the only precaution you can resort to. But to show how easily an accident may occur in a colliery when it is expected that boring is going on, I will quote a case which happened in my district in Cheshire not very long ago. On visiting this colliery, and seeing everything with regard to the ventilation, I put a question to the assistant underlooker (the underlooker himself was from home) as to whether he had any water to tap; he said, "Yes, we are about to tap some water now in the top of our rise workings." "Are you keeping proper bore holes in advance?" "Yes," he said, "we are keeping one." "Are you

you not keeping three," I said; "you ought to have one in the middle and two on each side?" He said, "We have only got one." I said, "We will go and see it." He said, "You may rely on its being all right." I said, "I have met with so many cases where boring is neglected, that we will see in what state we find the boring in this case." The mine was a very steep one, dipping at an angle of 45; and on climbing up to the top, I found the man had no bore hole whatever, and that he had just driven through a fault and upthrow of about three or four feet, which was a likely place for the old working, to have been stopped at, and he had no bore hole there at all. The proprietor was in the pit with me, and I asked him what he thought of it, and what he considered I must think of the management of the colliery. He said, he could only assure me that he was paying for boring, and that his underlooker being from home his assistant did not appear to be looking properly to the matter, and the men were receiving wages for boring which they were not doing.

927. Mr. *Locke.*] Were there any plans of the mine which you have just been alluding to?—In that case they had plans.

928. Were you able, then, to suggest some further bore holes to be made as a matter of precaution?—I had nothing to add to the suggestion I had made that there should be two bore holes, one on each side, in addition to the one going on in the centre of the drift.

929. You said you thought it desirable to be in possession of the plans, in order to judge better of what accumulation of water might take place?—I did.

930. In all cases the plan of a mine is of very great importance, to enable persons to judge where water might not accumulate?—I think it is most important; no one can carry on a mine properly without the assistance of a plan, and every one could carry it on better if he had the plan of the workings to guide him.

931. And would be able to judge of the safety and security of the mine, if he had a plan of what had been done in previous years?—That is my opinion.

932. *Chairman.*] Without plans it would be impossible for any owner of a colliery to know whether he was confining himself to his own limits or not; he might work over his own boundary; if he had no plans he could not tell whether he was in his own ground or not?—There are cases of that kind, although they are very rare; they generally dial it, and peg it out upon the surface. The pegs are soon pulled up; and when two or more seams are being worked in the same field, the complication is increased.

933. Mr. *Locke.*] Are you aware of a law with reference to one person abstracting or taking the coal of another; is it not penal?—It is felony.

934. In order to enable parties to avoid those penalties, the plan of the colliery would be almost an essential thing?—Yes; it is surprising what a number of cases we meet where encroachments have been made on other properties.

935. Mr. *H. A. Bruce.*] Have you ever heard of a man being tried for felony for encroaching on his neighbour's coal?—Yes; there was a colliery owner in Lancashire, who was tried and sentenced to transportation for seven years. I believe he was not sent out of the country.

936. *Chairman.*] Are you aware under what Act he was tried?—I cannot state the Act, but I have no doubt of the fact. I am not sure whether he was sent out of the country; but if he was he has returned, and has a colliery, which I was through very recently.

937. Mr. *Stephenson.*] There must have been something peculiar in this case which made the thing felony?—I think it is felony if the encroachment has been made wilfully.

938. Mr. *Baird.*] Was it a case of letting off water?—I do not think it was a case of letting off water; if I am correctly informed as to the case, he worked under Wigan Churchyard.

939. *Chairman.*] (To Mr. *Lancaster.*) Is Mr. Dickinson substantially correct?—I heard the case tried, and the colliery owner was sentenced to transportation for seven years.

940. Mr. *Locke.*] Were there any peculiar circumstances connected with that case?—I believe he had been under 21 different properties, and got coal from them without paying.

941. Mr. *Cayley.*] It was made out that he had not been accidentally trespassing, but knowingly stealing coal?—He had been stealing; and I happened to make the remark when he spoke to me afterwards, before he was tried,

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"How could you do such a thing?" and he said, "I did not think I was stealing; I intended to pay for it at some time."

942. *Chairman.*] (To Mr. *Dickinson.*) You have stated the two points you would insist on as to the mode of inspection, the giving the inspector the power of stopping the mine in cases of extreme danger, and to enforce proper penalties; is there any other point to which you wish to call the attention of the Committee?—There is another; the present Act for the inspection of coal mines refers only to persons employed in or about collieries, and does not apply to the public. A colliery which is worked out, or which is standing, may have many of the shafts belonging to it unfenced, and in a very dangerous state, so far as the public are concerned, and also so far as the workmen of other collieries are concerned, who have to pass over that colliery to get to their work. Cases of that kind are common enough in Staffordshire; and the inspector is not authorised under the present Act to interfere in such a case, he has no more power than another person.

943. You would give the inspector power to order these pits to be properly fenced round, that the public should be protected from accident, and also give him the power of enforcing a penalty if his orders were not provided for?—Yes, the fencing of the pits is one of the regulations which I have laid down in the code which I think ought to be carried out in every case; and I think that in cases of that kind the Act ought to apply to the public, as well as to the persons employed in and about a colliery.

944. Mr. *Locke.*] Would you limit that to pits only, or extend it to stone quarries and various other things that exist, equally dangerous in all parts of the country?—It would be desirable to extend it to pits of all descriptions; as we were speaking now of coal mines only, I have limited it to that.

945. Suppose a limit were given to coal mines, do you see why the coal pit should be fenced off, and other things, such as stone quarries, should not be fenced off?—I think they should all be fenced. If you have seen the Staffordshire pits, you will know that there are many footpaths passing close to an open pit without any fencing about it, and every person who tumbles into these old pits is not known. There was one case, when I had the charge of the Staffordshire district, of a skeleton being pulled out of a pit, and there was great uncertainty as to whose remains it was.

946. *Chairman.*] Pits are much more dangerous than quarries?—Pits are much more dangerous.

947. Grass could grow over a pit so that a man could not see what it was?—Yes; unfenced pits are the greatest evils in Denbighshire; I succeeded in getting 84 pits filled up or fenced in one colliery alone.

948. When accidents occur, the proprietor of the mine, by the present Act of Parliament, is obliged to send notice of that accident to the Secretary of State?—Yes; every life which is lost must be so reported within 24 hours after the occurrence of the death.

949. Then the Secretary of State communicates with the inspector of the district?—That is the way in which we receive information of it.

950. Would it be an improvement or not if the notice were sent direct to the inspector, at the same time as the one was sent to the Secretary of State?—It would save time if such an arrangement were come to, and would add very little trouble to the colliery proprietors. It is very desirable it should be done.

951. Would the time thus saved be of material importance?—In some cases it would; it would enable us to attend some inquests, which now there is not time to attend.

952. Mr. *Locke.*] Give a case where you have not been able to attend an inquest, in consequence of the delay arising from the transmission of orders from the Secretary of State?—In one instance the coroner administered a lecture on my absence, and also attributed neglect to the Government in not having sent down an inspector, when that inquest was being held, before it was possible for me to have received notice of the accident; and the inquest was finished before I received any notice whatever of it.

953. Mr. *Fitzroy.*] Is not the inquest usually adjourned, for the purpose of your attendance, if you are not present at the first commencement of it?—As a general rule it is; but if 48 hours have elapsed, the coroner is not bound to adjourn it, and in some cases he does not.

954. Mr.

954. Mr. *Locke.*] In a case of so much importance, is it not desirable that it should be adjourned?—It is very desirable it should.

955. Do you not think that would be a better mode of eliciting the truth, giving sufficient time for the inquiry, rather than it should be hurriedly proceeded with; and that instructions should be sent directly from the owner of the pit to the inspector?—It very often is a very great advantage to the inspector to be early at the scene of the accident, as he is able to see the circumstances exactly as they were at the time of the accident; whereas, if two or three days elapse (which do elapse under the present system) the circumstances under which the accident happened may have been very much altered.

956. That is one of the circumstances which would justify you in giving that recommendation, whatever other inconveniences there may be, in the order not passing through the Secretary of State's Office?—It is; but I would still have a notice to pass through the Secretary of State's Office, in the usual way.

957. *Chairman.*] Can you conceive any inconvenience from adopting such a plan?—Not any; indeed in some cases it is done now.

958. You, in conjunction with Mr. Dunn, Mr. Mackworth, and Mr. Wynne, made some experiments with reference to the steam-jet and furnace power, at Seaton Delaval Colliery?—I did.

959. When was that?—On the 15th and 16th December last.

960. Did you go in consequence of any order by the Secretary of State?—No, we had no order from the Secretary of State; but Mr. Wood was at that time making some very extensive experiments at Hetton and Killingworth; those experiments which he undertook to make in his evidence of 1852; and we went down with the view of seeing them, and also with a view of seeing the experiments which Mr. Forster also undertook to make at South Hetton, as a check upon Mr. Wood's; and being in the neighbourhood, we were naturally anxious to see Seaton Delaval, which had been put forward in two Parliamentary Committees as the chef-d'œuvre of steam-jet ventilation.

961. Mr. Forster is the manager of Seaton Delaval?—The manager and viewer.

962. Did you apprise Mr. Forster of your intention of going there?—We did. Mr. Dunn wished us to write a general letter; we said, "You are the inspector of the district, and the letter had better go in your name." The letter was accordingly sent, requesting permission to visit Seaton Delaval and South Hetton. We were informed in reply that the arrangements at South Hetton were not completed; and it was stated that as there was such a prejudice against the steam-jet, Mr. Forster would very much prefer if we would postpone our visit to Seaton Delaval Colliery until he was able to accompany us himself, being laid up at the time from an accident.

963. Did you in consequence postpone your visit?—We discussed his answer over; and we thought as we were all then present, and it would not be convenient for us all to meet there again without very great loss of time, and as in these northern collieries there is always an intelligent resident viewer as well as a principal viewer, and as we went there without any bias whatever, but simply with the intention of testing the facts with respect to the ventilation, therefore we wrote a second letter to him.

964. When you visited Seaton Delaval Mr. Forster was not present?—No.

965. You were accompanied by the resident viewer?—Yes, and also by the overman, and also the predecessor of either Mr. Forster or Mr. Lamb.

966. Did you make any experiments on the ventilation of the steam-jet?—We did.

967. State the results of those experiments?—This is the report which we made on it.

968. Mr. *Fitzroy.*] Was this the first experiment you had ever been present at of the steam-jet?—No, it was not; I had been present at other experiments of the steam-jet in other collieries.

969. Mr. *Cayley.*] Where had you seen it?—At the Wardley pits, in the Worsley Colliery, in Lancashire, where 90 steam-jets were tried first at five yards from the top, and afterwards lower down. I had also seen it in operation at the Duffryn Colliery, and at other places; I think the first application I had ever seen of it was at the Dowlais Colliery.

970. *Chairman.*] At Seaton Delaval it was applied in a superior manner, and in an improved manner to the others you had seen?—It was.

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971. State to the Committee the result of your experiments?—I may state this: that the Seaton Delaval application of the steam-jet is not one of the best I have seen; I think the jets, as recently applied by Mr. Darlington, at Ince Hall, are done in a superior manner to Seaton Delaval.

972. Have you in your hand the report of those experiments?—This is the report of the Seaton Delaval experiments.

973. Which way was the steam-jet applied at Seaton Delaval?—It is all set forth in the report.

974. Mr. *Locke.*] What was the depth of the main shaft at Seaton Delaval?—The colliery is ventilated by four down-cast shafts and one up-cast shaft, each eight feet in diameter, and 212 yards in depth.

975. What is the average distance from the four down-cast shafts to the up-cast shaft?—They are all in a group together.

976. *Chairman.*] How many splits of air are there?—Three main splits.

977. Mr. *Locke.*] What is the distance that the air has to travel underground from the down-cast shaft to the up-cast?—The longest split is seven thousand six hundred and fifty yards.

978. I should still like to know what the distance was between the two shafts; you have given us the course of the air; what is the absolute distance between the two shafts?—We did not measure it, but I should think about 100 yards.

979. *Chairman.*] What is the ventilating power at Seaton Delaval?—Four boiler-fires, 33 steam-jets, and the discharged steam from an underground engine, and a gas apparatus, of which five retorts are kept at work, all placed near the bottom of the up-cast shaft.

980. In addition to the steam-jet, these boiler fires tend to the rarefaction of the air in the shaft?—No doubt of it.

981. Describe the operation of the steam-jet?—I think it acts partly by propulsion, and partly by rarefaction.

982. Where is the steam-jet placed at Seaton Delaval?—Close to the bottom of the up-cast pit.

983. Mr. *H. A. Bruce.*] There are a great number of steam-jets; are they all in the same place?—They are placed on radial arms.

984. All at the bottom of the pit?—All at the bottom of the pit.

985. Mr. *Locke.*] When you said, placed at the bottom of the pit, how far from the floor of the mine, or from the roof of the mine?—It may be about 20 feet above the roof. I did not measure that, but I should suppose about 20 feet.

986. *Chairman.*] In the pit?—Yes.

987. State to the Committee the experiments that you made, and the greatest velocity of air you obtained?—I may state that we took our measurements twice. Finding those of the first day differ so very materially from those which had been put forward by Mr. Forster and others, we determined to repeat them the following day. We did so, and with numerous checks. We measured the air twice in the up-cast pit, both which measurements correspond very nearly together. We also measured the air twice over in the different splits, and all these different measurements agreed very closely together. The following is an abstract: "Total air going into the workings, with the 33 steam-jets, 4 boiler fires, and gas apparatus at work: temperature of up-cast, 130°; temperature of down-cast, 42°; difference of temperature between down-cast and up-cast, 88°. Water-gauge, $1\frac{51}{100}$ inches. Barometer, $28\frac{1}{2}$ inches; 33,626 cubic feet of air per minute.—Total air going into the workings without the jets; temperature of the up-cast shaft 120°; temperature of down-cast, 45°; difference of temperature of up-cast and down-cast, 75°; 29,999 cubic feet of air per minute.—Increase by jets and an increase of 13° of temperature between the up-cast and down-cast on the 16th of December, 3,627 cubic feet of air per minute.—Increase by jets on the 15th of December, 3,474 cubic feet of air per minute.—Increase of water gauge by jets and temperature 16th of December, $1\frac{51}{100} - 1\frac{21}{100} = \frac{30}{100}$ inch. Amount of air obtained per lb. of coals consumed by the boiler fires and gas apparatus, 1,372 cubic feet."

988. At what part of the up-cast was the temperature measured?—At 30 yards.

989. Mr. *Stephenson.*] From the surface?—Yes.

990. Did you not take the temperature down at the bottom also?—We did not;

not; we could not well get it; in the middle of the shaft is the proper place to take the temperature. You cannot do that without a registering thermometer; and they are all so liable to get out of order, that we preferred taking it near the top.

991. Have you based any calculation of the quantity of air that would be discharged by the up-cast on that data?—We have not.

992. You have made no use of them, but merely as the records of the fact?—Merely as a comparison of temperatures; all the temperatures being taken at the same depth in the shaft.

993. *Chairman.*] Is that the report that you have in your hand?—It is.

[*The Witness delivered in the following Report:*]

The colliery is ventilated by four down-cast shafts and one up-cast shaft, each eight feet in diameter and 212 yards in depth.

There are three main splits of air.

The engine plane split is 7,650 yards in length; average of smallest area, 80 square feet, at one point, through a whin dyke, the area being 45 feet. It is subdivided at the furthest part of the course, and before reaching a fall of roof, which had taken place about the 22d of November, and which was examined at the time of the experiments, and found to offer no appreciable obstruction to the free passage of air: a result which also appears by the measurement of air on the 11th of December, as taken by the master wasteman, and entered in the colliery book, which shows a partial increase.

The Victoria split is 4,400 yards in length; average area, 80 square feet, and it passes through regulators.

The boiler-fires split is 100 yards in length, and passes through a regulator $2\frac{1}{3}$ square feet area.

The ventilating power consists of four boiler fires, 33 steam-jets, the discharged steam from an engine, and a gas apparatus, of which five retorts are kept at work, all placed near the bottom of the up-cast shaft.

Two of the boilers are each 25 feet long, six feet diameter, spherical ends, wheel flues; the other two are each 32 feet long by five feet diameter, spherical ends; fire surface, five feet by four feet, wheel flues.

The boiler bottoms are about four feet above the fire-bars.

The four boilers are connected, and work an underground engine of 27-inch cylinder and five feet stroke; nominal power, of 60 horses.

Two drifts of 80 square feet area discharge the products of combustion and the return air into the shaft, in one of which is the exhaust-pipe, seven inches in diameter.

When the engine is not at work, the boiler-fires split is partially closed, and the fires slacked. The jets are at work night and day.

The stated consumption of fuel for the four boiler-fires and five gas retorts is at the rate of 42 tubs of $7\frac{1}{2}$ cwt. each per day; pressure of steam, 35 lbs. per square inch. Besides the engineer, one man and two boys are employed at the boiler-fires in the day, and one man at night. There are 33 steam-jets, without tubes or cylinders, placed in eight radial arms, four in each arm, and one in the centre; they are $\frac{3}{16}$ inch in diameter, and 205 yards from the top of the shaft.

Abstract of the Amount of Ventilation as taken from the Colliery Book.

	Engine Plane.	Victoria.	Engines.	Total.
1851:	*Cubic Feet.*	*Cubic Feet.*	*Cubic Feet.*	*Cubic Feet.*
25 November - -	38,571	15,428	18,000	71,999
30 November - -	38,571	16,615	18,000	73,186
1852:				
15 April - - -	44,274	7,290	18,000	69,564
29 June - - -	45,818	9,317	18,000	73,135
30 October - -	45,818	12,480	19,636	77,934
11 December - -	45,818	14,400	20,000	80,218

The fourth boiler has been at work for about five weeks.

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FIRST EXPERIMENT, 15th of December.

Present, Messrs. Dunn, Dickinson, Mackworth, Wynne (inspectors); Lamb, resident viewer; Robinson, master wasteman; and overmen, &c.; with steam-jets, four boiler fires, and five retorts at work.

AMOUNT of Ventilation taken in the Three Splits, with Three Anemometers, simultaneously.

	Velocity, per Minute, in Feet.		Area, in Feet.		Cubic Feet of Air per Minute.
Engine Plane Split - - - - -	196	×	72	=	14,112
Victoria - ditto - - - - -	150	×	54	=	8,100
TOTAL Air going into the Workings - -					22,212

The above measurements corrected for the friction of the anemometers:

	Velocity.		Friction, in Feet.		Area.		Cubic Feet of Air per Minute.
Engine Plane Split - - -	(196	+	38)	×	72	=	16,848
Victoria - ditto - - -	(150	+	98)	×	54	=	13,392
TOTAL Air going into the workings - -							30,240

	Velocity.		Area, in Feet.		
Boiler Fires Split - - - -	3,721	×	$2\frac{1}{3}$	=	8,682
TOTAL Air going through the Shafts - -					38,922

Water-gauge in drift, 880 yards long; between bottom of up-cast and down-cast shafts, $1\frac{50}{100}$ inches.

SECOND EXPERIMENT, 15th of December, without the Steam-jets.

The Jets were shut off at 12 h. 49 m. Experiment at 2 P. M. Correcting as before for the friction of the anemometers.

	Velocity.		Friction.		Area.		Cubic Feet of Air per Minute.
Engine Plane Split - - -	(172	+	34)	×	72	=	14,832
Victoria - ditto - - -	(125	+	96)	×	54	=	11,934
TOTAL Air going into the Workings - -							26,766
Boiler Fires Split - - -	(116	+	95)	×	58	=	12,238
TOTAL Air going through the Shafts - -							39,004

	Cubic Feet of Air per Minute.
TOTAL Air going through the Workings with the Steam-jets at work - -	30,240
TOTAL Air going through the Workings without the Jets - - - -	26,766
INCREASE by the Jets - - -	3,474

Water-gauge

Water-gauge at 2 h. 0 m., $1\frac{32}{100}$ inches; increase of water-gauge by the jets, $1\frac{50}{100} - 1\frac{32}{100} = \frac{18}{100}$ inch.

Temperature of down-cast air, 47°.

Mean temperature of the air in the mine, where the experiments were taken, 55°.

Simpiesometer, $29\frac{20}{100}$ inches.

The thermometer in the up-cast fell down the shaft before any observations were taken.

16th of December.—Present, the same persons as on the 15th.

FIRST EXPERIMENT.

Air measured with one anemometer in the up-cast shaft, at 10 yards from the top.
Velocity, 1,008 $\frac{1}{3}$ feet per minute, × 50 $\frac{1}{4}$ square feet area, = 50,669 cubic feet per minute.
Barometer at 28 $\frac{1}{2}$ inches.

Temperature of downcast air - - - - - - - - -	42°	
Ditto - of up-cast shaft, at 30 yards below the top - - - - -		130°
Average temperature of the air in the mine when the experiments were taken		50°
Difference of temperature - - - - - - -		80°

Allowing $\frac{1}{480}$ for expansion of air, for a degree of heat at 32° gives 130° — 32° = 98°, and 50° — 32° = 18°; then 480 + 98°: 480 + 18° = 50,669 cubic feet: 43,656 cubic feet.

43,656 cubic feet is the volume of air in the mine, at a temperature of 50°, obtained from the measurement in the up-cast shaft, no allowance being made for the friction of the anemometer.

SECOND EXPERIMENT, 16th of December.

With steam-jets, 4 boiler fires, and 5 gas retorts at work.
Taken simultaneously in the 3 splits, with 3 anemometers, at 12 h. 30 m., p. m., and corrected, as before, for the friction of the anemometers.

	Velocity.	Feet, Friction.			
Engine Plane Split - -	(297	+ 5)	× 67	=	20,234
Victoria ditto - - -	(150	+ 98)	× 54	=	13,392
TOTAL Air going into the Workings - -					33,626
Boiler fires split, 207 × 58, taken by the colliery anemometer, which shows too high a velocity for air - - - -					12,006
TOTAL Air going through the Shafts - -					45,632

Temperature of up-cast - - - - - - - - -	130°
Ditto - of downcast - - - - - - - -	42°
Difference - -	88°

Water-gauge, $1\frac{51}{100}$ inch, at 12 h. 30 m. p. m.

	Cubic Feet.
Total air, in 3 splits, as above, at 50° - - - - -	45,632
Air in up-cast, corrected to 50°, as per preceding experiment -	43,656
Difference between this measurement and the preceding one -	1,976

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THIRD EXPERIMENT, 16th of December.

With steam jets, 4 boiler fires, and 5 gas retorts at work.

Measurements taken by the agents of the colliery, in the presence of the inspectors, with powder smoke, on walled headings, 60 feet long, at 3 p. m.

	Feet, per Minute.		Area in Feet.		Cubic Feet.
Engine Plane Split - - - - -	400	×	67	=	26,800
Victoria ditto - - - - -	257	×	52	=	13,364
TOTAL Air going into the Workings - -					40,164

Measurements taken at the same time with the anemometer gave—

	Velocity.		Friction in Feet.				
Engine Plane Split - -	(390	+	5)	×	67	=	26,465
Victoria - ditto - -	(245	+	5)	×	52	=	13,000
TOTAL Air going into the Workings - - -							39,465

The trial by powder smoke gave therefore a higher result by 699 cubic feet per minute.

The measurements by powder smoke were taken at separate times, and the boiler-fires split did not admit of being measured with powder smoke. It is evident that at the times these measurements were taken the air was distributed in a different manner. The measurements afford, however, a means of calculating the ventilation which would have been indicated by powder smoke if it had been applied at the several splits simultaneously.

	Amount of Air by Anemometer.		Amount of Air by Powder Smoke.		Amount by Anemometers. Simultaneous Observation.		Amount of Air which would have been shown by Powder Smoke, had the splits been measured simultaneously.	
Engine Plane - -	26,465	:	26,800	: :	20,234	:	20,490	
Victoria - - -	13,000	:	13,364	: :	13,392	:	13,766	
TOTAL Air going into the Workings, if taken simultaneously by powder smoke - - -							34,256	Cubic Feet.
Boiler Fire Split, adding the first two ratios -	39,465	:	40,164	=	12,006	:	12,210	
TOTAL Air passing through the shafts, if taken simultaneously by powder smoke - - -							46,466	Cubic Feet.

FOURTH EXPERIMENT, 16th of December.

Without the steam-jets. The jets were stopped at 4h. 30m. p.m., the opening for the split to the boiler fires being nearly closed, the engine stopped working, and the boiler fires checked. The measurements were taken simultaneously with three anemometers at 6h. 30m. p.m., corrected for the friction of the anemometers as before.

	Velocity.		Friction, Feet.		Area in Feet.		Cubic Feet per Minute.
Engine Plane Split - - -	(261	+	5)	×	67	=	17,822
Victoria - ditto - -	(128½	+	97)	×	54	=	12,177
TOTAL Air going into the Workings - - -							29,999
Boiler fires split - - - - -			51	×	58	=	2,958
TOTAL Air passing through the Shafts - - -							32,957

Water-gauge, 1 $\frac{21}{100}$ inches.

Temperature of Up-cast Shaft - - - - - - -	120°
Ditto - - Downcast - - - - - - -	45°
Difference - - -	75°

Coals Used.

Quantity stated by the resident viewer at 35 tubs in 24 hours for 3 boilers and the gas retorts, the coke from the retorts being used in the boiler fires, and one-fifth more for the fourth boiler, viz., 42 tubs:

42 tubs each 7½ cwt. = 35,280 lbs. per 24 hours, or 24½ lbs. per minute.

With the Jets on, Cubic Feet of Air passing through the Shafts per Minute.		Lbs. of Coals.		
45,632	÷	24½	=	1,862 cubic feet of air per lb. of coals.

With the Jets on, Cubic Feet of Air going into the Workings per Minute.		Lbs. of Coals.		
33,626	÷	24½	=	1,372 cubic feet of air per lb. of coals.

But as the consumption of coals is much above the average when the jets are on, and the engine working, the actual economy of ventilation is much below this.

Allowing 300 cubic feet of air as the quantity usually employed for the combustion of 1 lb. of coals, 24½ lbs. × 300 cubic feet = 7,350 cubic feet, the quantity taken from the boiler fires split to feed the fires. It is evident that in the last experiment made without the jets that the boiler fires, with a split of only 2,958 cubic feet of air must have been very low.

Assuming each boiler at 30-horse power, 3,400 cubic feet of steam must have been given off per minute at atmospheric pressure.

In conclusion, we beg to present the following summary of the ventilation of the Seaton Delaval Colliery:

	Cubic Feet of Air per Minute.
Total air going into the workings with the 33 steam jets, 4 boiler fires, and gas apparatus at work. Temperature of up-cast, 130°; temperature of down-cast, 42°; difference of temperature between down-cast and up-cast, 88°. Water gauge, 1 51/100 inches. Barometer, 28½ inches -	33,626
Total air going into the workings without the jets; temperature of the up-cast shaft, 120°; temperature of down-cast, 45°; difference of temperature of up-cast and down-cast, 75° - - - - - - - - - -	29,999
Increase by jets and an increase of 13° of temperature between the up-cast and down-cast on the 16th of December - - - - -	3,627
Increase by jets on the 15th of December - - - - - -	3,474

Increase of water gauge by jets and temperature 16th of December, 1 51/100 — 1 21/100 = 30/100 inch.

	Cubic Feet.
Amount of air obtained per lb. of coals consumed by the boiler fires and gas apparatus - - - - - - - - - - - - -	1,372

994. Mr. *Locke.*] What was the amount of air passing through the mine?—33,626 cubic feet per minute.

995. *Chairman.*] Under what circumstances?—That was with the jets, with the boiler fires, and the gas apparatus at work.

996. Mr. *Locke.*] At what temperature was air admitted into the down-cast shafts?—At 42 degrees.

997. And you have not the temperature of the air as it passed over the jets, but you have it within 30 yards of the top of the pit?—It was there 130 degrees.

998. Where did you measure the current of air, in order to ascertain that quantity?—In the workings. I measured the large intake as the air was going into the mine, about half a mile from the shaft.

999. What do you mean by the large intake?—The principal split of air before it is distributed. We took the temperature of the different splits as measured.

1000. In this mine-way you would have the combined quantities of the four down-cast shafts?—Yes; four down-casts.

1001. All concentrated in that mine drift-way?—Yes; but there were other

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two splits, in addition to this one, all of which received a portion of the air from those down-cast pits.

1002. This way you speak of was not the only one?—No, it was not the only one; it was the main split.

1003. You took the velocity in that air-way and in the other air-ways coming from the four down-cast pits?—Yes.

1004. Was there any material variation in the temperature of the air in that distance?—There was no material variation.

1005. Did you take the temperature there when you took the velocity?—Yes; we took the temperatures there also.

1006. You took the temperature, from which you made your calculation, at the spot?—Yes.

1007. Shall we find in that report the mean of all these three drift-ways, and the velocities from which you deduced the quantity of air passing through the mine?—Yes; all these particulars are given, and the friction of the anemometers is also shown.

1008. How do they work the mine at Seaton Delaval, is it pillar and stall, or long work?—It is pillar and stall; the ordinary work of the north of England.

1009. Are there many stoppings or traps in that mine; in 7,000 yards, for instance?—There are a large number of stoppings.

1010. Is it one of those pits where you will find, on an average, that there is as much friction and resistance to the passage of air as in ordinary cases?—Yes; I should consider it an ordinary sample.

1011. Mr. *Stephenson.*] Of the pillar and stall?—Yes.

1012. Is there more friction in the pillar and stall way of working, than in the long way of working?—Yes; I stated that fully at the commencement of my evidence; I am now speaking of pillar and stall collieries.

1013. Mr. *Locke.*] In drawing a comparison with any other system of ventilation, it should be borne in mind that the friction and resistance, being the matter to be overcome, is the question to be taken into consideration in estimating the value of the means employed?—No doubt of it.

1014. *Chairman.*] How did you ascertain the exact value of the steam-jet in your experiments, because in your report you seem to have had the steam-jet, four boiler fires, and five retorts at work at the same time?—We next stopped the jets to ascertain what amount there was without them.

1015. Mr. *Locke.*] Before you leave the jets, what was the elasticity of the steam as applied to the jets during the operation; during the time you were measuring the quantity of air, what was the pressure on the valve?—These are all set forth fully in the report; 35 lbs. to the inch.

1016. Was all the steam passing off into the steam-jets that was generated in those four boilers?—The four boilers were used to work the under-ground engine.

1017. Were the four boilers connected simply with the steam-jet, or was the steam from them used for any other purpose?—It was used for working an under-ground engine also.

1018. Could you give any notion as to what quantity of the steam was abstracted from the boilers for the use of the engine, and that which passed off to the jet?—I have not gone into the question to separate it.

1019. *Chairman.*] The discharged steam from the engine passes up the pit?—The discharged steam did; it was discharged into the returned air drift, and went up the pit with the returned air.

1020. Mr. *Locke.*] Was there any steam passing into jets other than that coming from the engine?—The jets were fed from the boilers direct.

1021. As well as from the issues of steam coming from the engine?—The jets were not at all fed by the steam from the engine.

1022. Have you made any dissection of the quantity of air that has passed up, to see what was due to the steam-jet, and what was due to other causes, namely, furnaces, and the issuing of steam from the engine?—In the second day's experiments the increase with the jets and 13° of temperature was 3,627 cubic feet per minute. On the former day the increase was 3,474 cubic feet, but in consequence of the thermometer being dropped down the pit the temperature was not ascertained.

1023. Mr. *Stephenson.*] Under the same circumstances?—The measurements were taken under the same circumstances.

1024. *Chairman.*] Did you try any experiment of putting out the retorts, stopping the engine, and applying only the boilers to supply the steam-jet?—We did not; it would have been impossible to have worked the steam-jet without having the fire under the boilers.

1025. Having the fires under the boilers and stopping the engine, and putting out the gas retorts?—We did not.

1026. Mr. *Locke.*] In point of fact, so far as a simple steam-jet is concerned, you did not try that experiment?—We did not try that experiment.

1027. *Chairman.*] Do you not think, having all these powers at work, this engine pumping steam up the up-cast shaft, the rarefaction of the air caused by the boiler fires and the retorts would not create a certain current of air, that would prevent the power of the steam-jet in aid of it being fairly tested?—The first quantity of air we ascertained, is the quantity of air with the steam-jet and these united powers at work; the second quantity is with these united powers at work, without the steam-jet; and the difference between the two is the increase which is due to the steam-jet.

1028. Mr. *Locke.*] From your figures, what was that?—In one case it was 3,627 cubic feet, and in the other 3,474 cubic feet, per minute.

1029. Upon an aggregate of upwards of 30,000?—Yes.

1030. You make the deduction from that experiment, that the jets were, in the proportion to the others, as 1 to 10 in ventilating power?—That was about the increase that the jets gave to the ventilation; but there was a material difference in the temperature of the up-cast also, which in itself might account for a considerable proportion of the increase.

1031. Might not that have arisen from the steam-jets themselves?—Partly from the steam-jets, and partly from a larger supply of fresh air being sent to the boiler fires when the jets were in work, which caused a more perfect combustion of the fuel, and raised the temperature of the up-cast shaft.

1032. When there was a large quantity of air passing to the furnace fires, was it in consequence of the steam-jet?—Partly in consequence of the steam-jets, and partly in consequence of more steam being required when the engine was at work. With the engine standing, it was necessary to shut the dampers.

1033. Do you know any other cause for raising the temperature in the up-cast shaft excepting the use of the steam-jets in the experiments you tried?—Yes; I think, in addition to the temperature which would be obtained from the steam coming out of the jets, that there would be a larger quantity of air passing through the boiler fires, which would have the effect of creating a more perfect combustion of coal, and of increasing the temperature of the up-cast shaft.

1034. You do not think that that increased quantity of air passing through the fires was due to the abstraction of steam by the use of the jet?—Not to that alone.

1035. Was it to any part?—Yes.

1036. Was it to a chief part, or to a small part, in your opinion?—I should not like to venture an opinion as to what proportion, I think it partly due to both.

1037. Mr. *Stephenson.*] When you have no steam-jet working, you shut the dampers of the boilers, do you not?—Yes; the dampers or the slide that regulates the supply of air to the boiler was closed, or partly so, when a large supply of steam was not required.

1038. When you put on the steam-jet you then had an increase of ventilation as a consequence?—Yes.

1039. But, in order to put on the steam-jet, you must consume two or three times the quantity of fuel under the boiler that you were consuming previously to putting the steam-jet on?—No doubt, with more air to the boiler fires, the consumption of coal is going on more rapidly and more perfectly.

1040. The increase of ventilation that took place when you put the steam-jet on, was the joint effort of the steam-jet, plus the coal consumed under the boilers?—Yes; and also the more perfect combustion of the coal, which is most important. In the Seaton Delaval up-cast the cloud of black smoke that rolls out of the top is only half consumed.

1041. In your report, the increase of ventilation which took place when the steam-

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steam-jet was turned on, would not be really the true representation of the increase due to the steam-jet?—No, it was due to the steam-jet, and to the increased temperature of 13 degrees.

1042. And to the large additional consumption of fuel under the boiler?—Yes.

1043. Therefore it was a joint effort; the increased size of the furnaces and the steam-jet?—Yes; it was due to the steam-jet, and also to an increased consumption of coal, and also to a more perfect combustion of coal.

1044. That would still leave the effect of the steam-jet less than apparently the report?—Yes.

1045. Did you measure the quantity of fuel that was being consumed under the boilers with the steam-jet at work, and without the steam-jet being at work?—We did not measure it.

1046. Mr. *Baird.*] You say you got 3,400 feet of additional current by the steam-jet, do you think any of that was carried by the propelling power of the steam, or was it entirely owing to the increased temperature of the up-shaft?—I think some of it was due to propulsion.

1047. Even so far down as that?—Yes.

1048. What portion?—I should not like to venture to separate those quantities; I should prefer not giving an opinion on it. The amount is so small as to be scarcely worth separating.

1049. Mr. *Locke.*] Have you formed any opinion as to what quantity of air would have passed up that shaft if you had employed the four boilers and the steam-jets only?—There are only the gas retorts in addition.

1050. And occasionally the steam-engine?—Yes; occasionally the discharged steam from the steam-engine. I think that, with one of these boiler fires, and a liberal supply of fresh air to it, and no steam whatever, I would undertake to send as much air up the pit as is now going by the entire powers that were at work.

1051. You were understood to have formed this opinion, that you could by means of those boilers, and by the rarefaction of the air passing from them, send more air up that pit than is now being sent up by those means, even with the additional use of the steam-jets?—I think I could; with those four boiler fires, and with a more liberal supply of fresh air to the boiler fires, I would materially increase the temperature in the up-cast pit, and draw more air through the workings.

1052. That you say, notwithstanding the experiments you have made, which show an increase of 10 per cent. by the use of the jets in the shaft?—Yes; but I should not recommend doing that with boiler fires, because by sending so much air to the fires you would burn your grates and boilers out.

1053. You think the proper mode of doing it would be to use the steam-jet as an auxiliary?—No; the proper way would be to put one eight-foot furnace at the bottom of the up-cast shaft, which would give more air than the whole of the powers now at work. I think one eight-foot furnace, properly constructed at the bottom of the up-cast shaft, would give more air than the whole of the powers now at work, and with a very much smaller consumption of fuel.

1054. Mr. *Stephenson.*] How far is the steam-engine from the bottom of the shaft?—It is not very far.

1055. Is it 50 yards?—Perhaps 50 yards.

1056. Then the steam is delivered from the engine after having performed its duties there, and does not come into the shaft?—It comes into the drift, and then into the shaft.

1057. Therefore, there is no additional power obtained from the exhausted steam of the engine?—I do not think there is much, if any additional power obtained from the exhausted steam of the engine, because in the split of air which I measured several times when the engine was running, and several times when it was standing, there was scarcely a perceptible difference in the quantities.

1058. *Chairman.*] Is there no additional velocity due to the waste steam from the engine?—Very little. There is a long train of about 100 waggons, which might retard or assist the current much more than the discharged steam.

1059. Mr. *Locke.*] In your report it is stated that there was a pressure of steam of 35 lbs. to the inch, at the boiler; during the time these experiments were made, was the engine at work or not?—Yes, the engine was at work; it

was at work at intervals, and standing at intervals; but it made no material difference in the quantities of air circulating through the different splits.

1060. Did it make any material difference in the pressure of the steam itself, and the boilers, as applied to the jets?—I think not, with four large boilers at work.

1061. Would the same quantity of steam be passing to the jets whether the engine was at work or not?—I should think the four boiler fires are adequate to the jets and the engine.

1062. And therefore you give it as your opinion that the pressure on the valve would be the same, and the elastic force of the jet would be the same, whether the engine was at work or not?—Yes; I think there would not be any material difference with such a supply of boiler power, and considering that the supply of air to the boiler fires was regulated to the quantity of steam required.

1063. Mr. *Cayley.*] Is it your opinion that high pressure steam would produce a power proportionate to the height compression, or elastic force of the steam?—In the experiments which I have made with steam-jets, it appears to me, the higher the pressure of the steam the greater the amount of propulsion obtained by it.

1064. You have stated, in this case at Seaton Delaval, there was only a pressure of 35 pounds to the inch?—Yes; all these things are stated in the report.

1065. Could you not have used a greater pressure if it was necessary?—I do not know whether we could or not. It was not stated to me whether it could be done or not; we took the usual pressure.

1066. Are not cylinders often worked with 100 pounds pressure to the inch?—We made our experiments under the ordinary circumstances in which the colliery was worked; we asked for no alteration; and I am not aware that any was made.

1067. In what way did the men connected with the mine assist you in your experiments?—There was one of the under-managers with each of us at the different splits where we took the measurements.

1068. Were they cognisant of all the instruments you used, and the mode in which you tested those experiments?—No, they were not; but we explained the use of them to them. They had an anemometer at the colliery, but did not know how to use it. They were not in the habit of measuring the air with the anemometer. I believe the air had never been measured before by the anemometer; it had always been measured by powder smoke, which is a very rough way, and liable to lead to very erroneous conclusions.

1069. Mr. Forster, last year, in his evidence, stated that he preferred the powder smoke to the anemometer?—I think he did; but the master-wasteman, Mr. Robinson, informed us during these experiments that he had been in the habit of taking all the measurements formerly. He also stated that he had supplied those measurements to Mr. Mather and Dr. Fife, when they visited the colliery.

1070. At what time of day did you make the experiments?—The hours are stated in the report, and all the measurements were taken simultaneously; therefore if one split had an increase of air, the other might have a decrease.

1071. When did you test these; did you make your experiments in the morning and your calculations in the evening?—We each of us measured one split, and made our own calculations in the morning, and in the evening we put all the calculations together into one total.

1072. Did you compare the materials on which you formed your conclusions before the men connected with the mine, before you drew your conclusions?—What materials?

1073. Whatever you formed your opinion on; the results of your experiments, the facts?—The underlookers and the resident agents were not with us at the time we made up the total result; but we furnished each of them with the quantities of the respective splits, as they were measured, and they had an opportunity of putting them together, and forming a total. Mr. Lamb, the resident viewer, was with me in the split which I was measuring, and he was taking down the quantities at the same time as I was taking them down myself.

1074. Did he assent to the truth of the facts you assumed, that the measurement was correct?—He did; and he also informed me that he had never before measured the Seaton Delaval air himself.

1075. You stated that you had two calculations; the calculations you made

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in the evening of the first day were not satisfactory, and you made some calculations on the second day?—In making out the total of the air going through the workings, it fell so far short of the total quantity of air which had been represented as passing through the Seaton Delaval Colliery, that we thought it better to repeat the experiments than to have the slightest doubt hanging over the question.

1076. Are we to understand that you repeated both the experiments and the calculations on the second day?—We did; and in addition to repeating the experiment a second time, we measured the total quantities of air at two different times in the up-cast shaft, both of which measurements agreed very closely with each other; and on deducting from those quantities the amount due to increased temperature, the amount agreed very closely with the quantities obtained from the measurements of the different splits.

1077. Then the result of your investigation is an opinion that the steam-jet can only operate as a power to the extent of 3,600 cubic feet per minute?—That is, the steam-jet with the additional temperature of the up-cast shaft, caused by the increased combustion of coal and the more perfect combustion.

1078. Do you attribute to the steam-jet a ventilating power only of 3,600 out of the 30,000?—I do not attribute that much to it.

1079. Is it your opinion that the steam-jet, as a ventilating power, is incapable of producing a greater increase of ventilation than that?—I think I have a series of experiments here which show that the steam-jet, with a more perfect combustion under the boiler fires, is capable of being better applied than it is at Seaton Delaval.

1080. Then the evidence that you wish to give is rather against the mode of the application of the steam-jet at Seaton Delaval Pit as to its power as a ventilator?—No; although I have a series of experiments with better results to put in, none of the experiments lead me to the conclusion that the steam-jet is so efficacious or so economical as the furnace.

1081. *Chairman.*] Did you ever make any experiments with the steam-jet alone, aided only by the caloric caused by the boilers which were necessary to generate the steam for the steam-jets?—With the boilers on the surface.

1082. Or below; the steam-jet and the apparatus connected with the steam-jet?—I have.

1083. Have you got the results of those?—I have; I may state that in taking these experiments, I had the assistance of Mr. Wynne, and the pits were standing during the time we made them, and we had every facility afforded to us by Mr. Darlington, the manager.

1084. Mr. *Cayley.*] What would the additional 13 degrees of temperature produce?—I have stated that I am not prepared to separate these quantities.

1085. How does furnace ventilation operate?—By rarefaction.

1086. What is your test of that rarefaction?—The thermometer in the up-cast pit; perfect combustion has also a great deal to do with the efficient working of the furnaces.

1087. What is the best gauge of the ventilating power?—The water-gauge is the test which is commonly used.

1088. What is the greatest extent of the variation of the water-gauge that you have ever known by the furnaces?—I have never seen, myself, two inches exceeded.

1089. You have stated that with the steam-jet, at the Seaton Delaval experiments, there was only the effect of about 1 ½ inch produced?—With the jets at work, the water-gauge was $1\frac{51}{100}$, and without the jets, and the other matters to which I have alluded, the water-gauge had fallen to $1\frac{21}{100}$, which was a decrease of $\frac{30}{100}$ of an inch.

1090. Is it your opinion that the steam-jet is incapable of producing a greater effect on the water-gauge than 1 ½ or 2 inches?—It appears that, if the water-gauge is taken very close to the steam-jets, that it has a most extraordinary effect on the water-gauge; but if taken at some distance from it, it has comparatively a very trifling effect.

1091. Do you remember seeing the experiments in the Polytechnic last year with the steam-jet?—Yes.

1092. And its effect on the water-gauge?—I do; that is one of the cases where the water-gauge was tried close to the jet, and in which the steam appears to have a peculiar effect.

1093. What

1093. What effect had that upon the water-gauge?—A very high water-gauge.

1094. To the extent of how many feet?—I do not recollect.

1095. Do you not recollect to the extent of 15 feet?—I cannot say; it was very high. There is a very peculiar power about the steam-jet when confined in a cylinder; it seems to concentrate the whole of its force into a particular point, and by that peculiarity and the power, it is able to counteract a very large increase of temperature, if the jet be applied through a small hole against this difference of temperature. I have seen it in a pit where the tops of both shafts have been closed, and only an opening of about a foot or 18 inches square at the top of each pit and the pipe inserted into those holes; one steam-jet blowing down the down-cast and one exhausting the up-cast; and acting in the pipes or cylinders. These two jets, and indeed one of them, proved sufficient to counteract a difference of temperature between the up-cast and down-cast of 103°, and propelled the current in the opposite direction. The quantity of air that was driven against this large balance of temperature was certainly very small, but it was perceptible, so that by concentrating its power the jet appears capable of counteracting temperature. It is like the steam-engine; if you reduce the speed, and work on the second motion, you may lift a greater weight than you could do with a more powerful engine applied on the first motion.

1096. What has temperature to do with the steam-jet when it is acting only as a propeller?—If it were shown that it acts only as a propeller it would have nothing to do with it; but in my opinion it acts both by propulsion and rarefaction; in this long series of experiments which I will put in, you will see that increased quantities of air have been accompanied by increased temperature in the up-cast shaft.

1097. Is it your opinion that if the steam-jet applies very great propelling power near to the jets, that power will not be communicated to the air next to it, and so onwards up the up-cast?—It is natural to suppose it would; but the air being so elastic, it does not appear to bear it out in practice.

1098. How long after the jets ceased, did you measure the quantity of air which was produced from what you describe as other causes than the steam-jets?—We found that in a very few minutes we got the maximum increase or decrease that takes place. There is no material increase or decrease in the quantity of air circulating through the working after a few minutes have transpired.

1099. No material alteration?—No material alteration; about 10 minutes seems quite sufficient to get the benefit of the full power. In the experiments I have made, I have allowed it to go on for a long time, and have observed that, after about a quarter of an hour, or at the utmost half an hour, there is no material increase or decrease. In this series of experiments, I have put in the exact time the experiments were taken.

1100. Mr. *H. A. Bruce.*] Did you consider the ventilation sufficient in that pit at the rate of about 33,000 feet a minute?—I was not the inspector of that district, therefore I gave no opinion; but considering the large quantity of coal raised, and the number of men at work, I think it must be too small.

1101. Was it susceptible of increase with those fires which they had?—I think a more liberal supply of fresh air to the boiler fires would have given an increase to the quantity of air circulating through the workings, but that is not the mode which I should have recommended for getting an increase. I should have preferred a furnace at the bottom of the up-cast pit.

1102. *Chairman.*] Were the air-ways sufficient to take through them an increased quantity of air?—Yes; if the air-ways were as large as stated by Mr. Forster, they were sufficiently large to take an increased quantity of air; and considering that the drag, as ascertained by the water-gauge, was only about an inch and a half, I think the air-ways must have been capable of allowing a larger quantity of air to be drawn through.

1103. Mr. *Stephenson.*] You have spoken of some experiments you made with the water-guage when the steam-jet was at work?—Yes.

1104. You also stated that the water-gauge stood at different heights, dependent upon its proximity to the steam-jet or being some distance from it?—The distance at which it is placed appears to make a very important difference with regard to the water-guage, and in steam-jet experiments I place no reliance on the water-gauge.

1105. Therefore the water-gauge, as applied to the power of ventilation with

J. Dickinson, Esq.

21 June 1853.

the steam-jet, is no criterion at all?—So far as my experiments have gone, they have led me to that conclusion.

1106. But you think the water-gauge is a fair criterion of the ventilating power of a shaft when heated by a furnace?—It seems a more certain criterion when heated by a furnace, but I am not quite clear whether the water-gauge is an accurate indication even for rarefaction alone.

1107. You preferred the anemometer rather than depend on the theoretical calculation of the water-gauge?—Yes.

1108. *Chairman.*] Did you make any other experiments in conjunction with any other inspector, with respect to the ventilation by steam-jet?—I have, at Ince Hall; Mr. Wynne assisted me throughout.

1109. Will you put in the result of those experiments?—Yes; I have two series of experiments made at the cannel coal pits of the Ince Hall Coal and Cannel Company:—"First, with regard to the experiments at the cannel pits. The ordinary ventilating arrangements consist of a furnace six feet across the bars; also two boiler fires, and the discharged steam from an underground engine. The boilers are each 40 feet long by 5 feet diameter, spherical ends; and together with the furnace are placed in the seam at the bottom of the up-cast shaft. There are three shafts about 200 yards deep; two being down-casts, the conjoint area of which is about 140 feet, and one up-cast 71 feet area. The air is coursed round the workings in three main splits of about 6,000, 6,000, and 3,000 yards in length. In addition to this ordinary ventilating power, the steam-jet was added in September 1852. It consisted of 14 jets, each $\frac{3}{8}$ inch diameter, striking into cylinders six feet long by one foot diameter, and placed 15 inches in front of the jets; and it was with this arrangement my first experiments were made on the 2d of December 1852. The jets have since been increased by the addition of four jets each $\frac{5}{16}$ inch diameter, as shown on the Sketch. The experiments on the 13th of January 1853 were made with this latter arrangement.

Vide annexed Sketch.

Ventilation of the Cannel Pits, Ince Hall Colliery. First Series of Experiments, with Boiler Fires, Steam-Jets, and Furnace, 2d of December 1852.	Temperature of Up-cast Shaft, eight yards from Top.	Temperature of Down-cast.	Water-gauge in Inches.	Cubic Feet of Air passed through the Workings per Minute.	Fresh Air to Boiler Fires.	Total Air passed through the Shafts.
1st. With two boiler fires, and steam blowing off at 50-lbs. pressure. Boilers each 40 feet long by five feet diameter -	115°	48°	$\frac{9}{10}$	25,991	2,701	28,692
2nd. With 14 steam-jets each $\frac{3}{8}$ inch diameter, in addition to the boiler fires, and steam blowing off at 50-lbs., as in No. 1 -	106°	48°	$1\frac{1}{10}$	33,031	2,553	35,584
Increase with the 14 jets at work - - - - -	- - -	- - -	- - -	8,040	—	—
3rd. With a six feet furnace and the boiler fires, and steam blowing off as in No. 1, but without the jets - - -	191°	45°	2	45,114	2,590	47,704
Increase by furnace - -	- - -	- - -	- - -	19,123	—	—
4th. With the furnace and 14 steam-jets, and the boiler fires, and steam blowing off at 50lbs. - - - - -	145°	45°	- - -	37,876	2,590	40,466

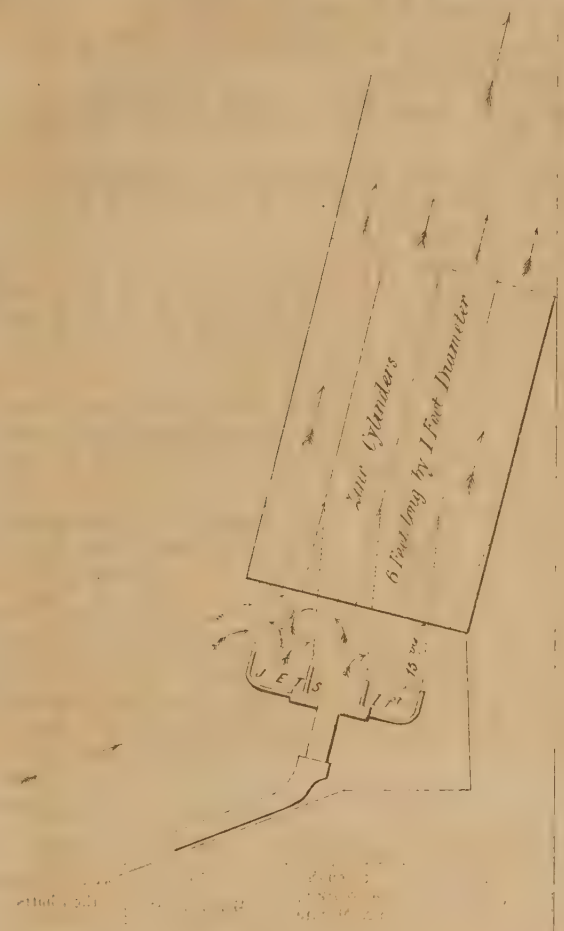
"In these experiments the united power of the furnace, steam-jets, and boiler fires, produced less effect than the furnace alone, the two powers seeming to baffle each other. This led to a series of experiments by which it was ascertained that by feeding the boiler fires with an abundant supply of fresh air, and with fresh air only, this anomaly could be obviated, and the powers of the jets and furnace worked harmoniously together.

On

[To face page 76.]

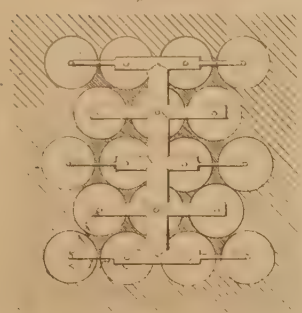
Sketch of the Steam Jet Apparatus as applied at the Cannel Pits, Ince Hall, Wigan.

Scale 3 Feet to an Inch.



UPCAST SHAFT.

Plan of the Jets and Cylinders



14 of the Jets are ¾ Inch diameter
4 — D° — D° — ⅝ — D° — D° —

* *Jets One Foot apart. Cylinders One Foot Diameter, and the interstices between the Cylinders are all made close.*

Joseph Dickinson
Inspector of Coal Mines
1853

№ 691. Ordered, by The House of Commons, to be Printed, 30th June, 1853.

"On the 13th of January 1853, some improvement having been made in the air-ways, and the number of jets increased to 18, as shown on the annexed Sketch, the experiments were resumed with the following result:—

Ventilation of the Cannel Pits, Ince Hall Colliery. Second Series of Experiments with Boiler Fires, and 18 Steam-Jets. 13th January 1853.	Temperature of Up-cast, eight yards from Top.	Temperature of Down-cast.	Difference of Temperature between Up-cast and Down-cast.	Cubic Feet of Air passed through the Workings per Minute.	Fresh Air to Boiler Fires.	Total Cubic feet of Air passed through Shafts per Minute.
1st. With boiler fires low, and no steam blowing off, taken at 12 a.m. This measurement was taken by anemometers in the down-cast shaft; the others were taken in the workings -	102°	46°	56°	25,703	1,400	27,103
2d. With good fires under the boilers, and the steam blowing off at the valves at 55 lbs. At 1 h. 30 m. p.m. - - -	112°	43°	69°	41,041	34,000	75,041
Increase by 13 degrees of temperature, and the steam blowing off at 55 lbs. -	- - -	- - -	- -	15,338	—	—
3d. With 18 steam-jets as per sketch, in addition to the boiler fires, and the steam blowing off at 60 lbs. At 2 h. 30 m. p.m.	130°	44°	86°	50,872	36,000	86,872
Increase by the jets and 5 lbs. higher pressure of steam, and 17 degrees of increased temperature as compared with No. 2 experiment - - -	- - -	- - -	- - -	9,831	—	—
4th. Same as No. 3, but with less fresh air sent to boiler fires. At 3 p.m. - - - - -	128°	45°	83°	50,794	28,400	79,194
Increase by the jets, and 14 degrees of increased temperature as compared with No. 2. - - - - -	- - -	- - -	- - -	9,753	—	—
5th. Same as No. 4, but with still less fresh air supplied to boiler fires. At 3.30 p.m. - -	121°	44°	77°	41,138	15,200	56,338
Increase by the jets, &c. and eight degrees of increased temperature, as compared with No. 2. - - - -	- - -	- - -	- - -	97	—	—

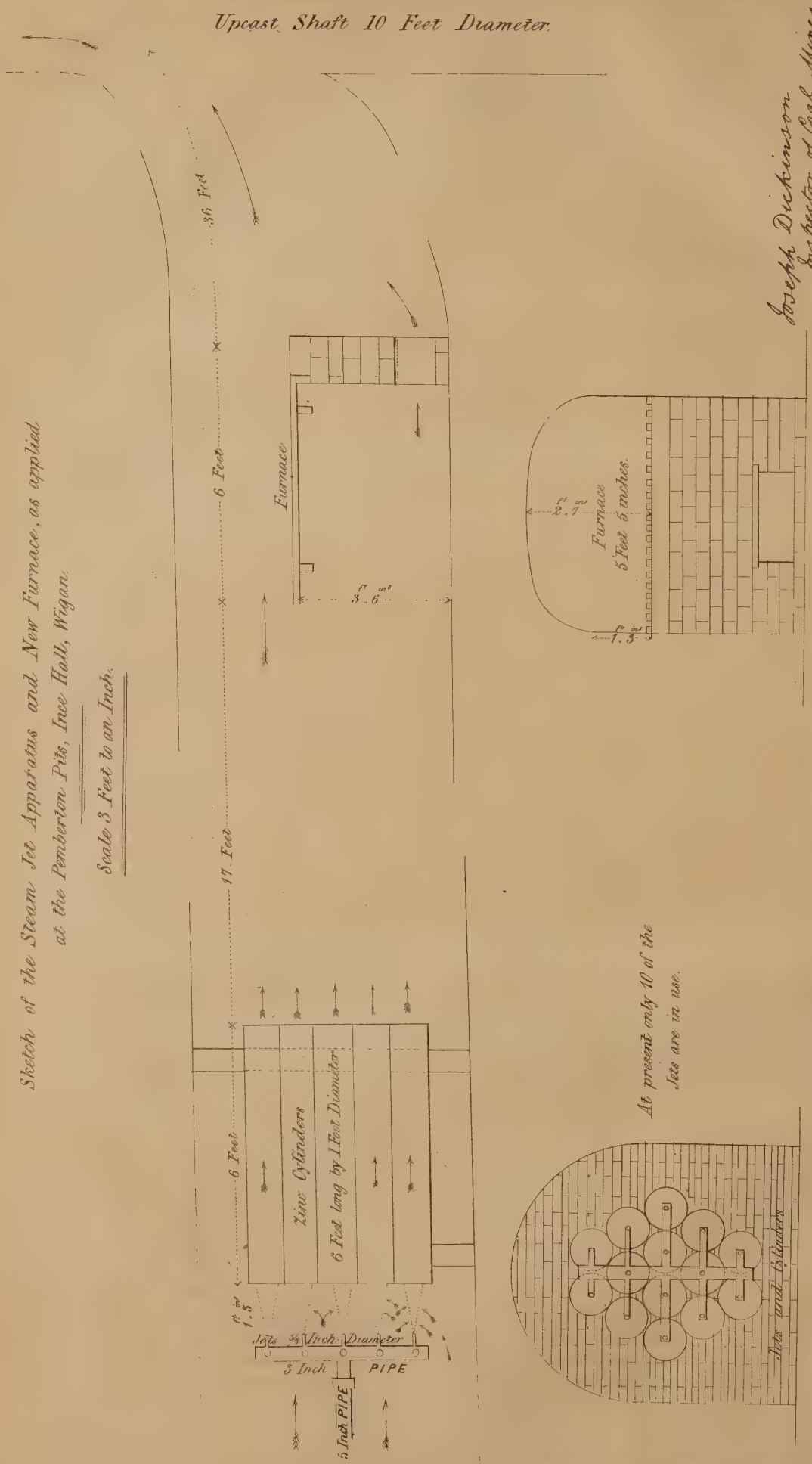
"On completing No. 5 experiment, at 3. 30 p. m., when the temperature of the up-cast was 121°, the boiler fires were slacked, and in a quarter of an hour the furnace was lighted, and at 3 h. 50 m. the temperature of the up-cast had fallen to 110°. The heat of the furnace then began to act, in addition to the boiler fires, and at 4 h. 30 m. the temperature was 178°. The boiler fires then began to get very low, and at 5 h. the temperature had declined to 174°, and at 5 h. 30 m., when the boiler fires, with the exception of a shovel full of fire which was reserved on the charging plate for relighting them, were entirely out, the temperature of the up-cast had further declined to 160°. From that time the furnace rapidly rose to its full power, and at 6 h. the temperature had increased to 180°, which was its maximum height. The furnace experiments were commenced at 5 h. 15 m., as follows:

Ventilation of the Cannel Pits, Ince Hall Colliery. Second Series of Experiments: The Furnace. 13th January 1853—*continued.*	Temperature of Up-cast.	Temperature of Down-cast.	Difference of Temperature between Up-cast and Down-cast Shafts	Cubic Feet of Air passed through the Workings per Minute.	Cubic Feet of Fresh Air to Furnace, and through Boiler Grates.	Total Cubic Feet of Air passed through the Shafts.
6th. With one furnace, six feet across the bars, the boiler fires being out; and allowing a large scale of fresh air, viz., 44,200 cubic feet, to pass through the boiler grates as a dumb drift, at 5. 15 p. m.	174°	42°	132°	48,311	44,200	92,511
Increase by furnace with 76° of additional temperature, as compared with No. 1 experiment				22,608	—	—
7th. With furnace as in No. 6, but with the doors open to allow the furnace also to draw fresh air, at 5. 35 p. m.	160°	42"	118°	40,466	48,080	88,546
Increase, with 62° additional temperature, as compared with No. 1				14,763	—	—
8th. Same as No. 6, but with only 15,600 feet of fresh air admitted through boiler drifts, at 6 p. m.	180°	42°	138°	46,781	15,600	62,381
Increase, with 82° additional temperature				21,078	—	—
9th. Same as No. 7, but with only 30,600 feet of fresh air admitted to furnace, and through the boiler drifts, at 6. 10	Not taken			44,534	30,600	75,134
10th. Same as No. 6, but with all the air passing through the workings in the way the furnace is ordinarily worked, at 6. 30 p. m.	180°	43°	137°	51,466	—	—
Increase, with 81° of additional temperature, as compared with No. 1.				25,763	—	—

"At 6. 45 p. m. the boilers were re-lighted, when the increase of temperature was soon sensibly felt at the top of the up-cast, and the thermometer by which the temperature was being taken burst; another thermometer was substituted, and it also burst; one of the thermometers indicated up to 220°, and the other to 235°; the temperature of the up-cast would therefore appear to have been above 235°, when the following experiments with the united powers of the furnace, boiler fires, and steam-jets were taken :—

Ventilation of the Cannel Pits, Ince Hall Colliery. Second Series of Experiments, Furnace, Boiler Fires, and Steam-Jets. 13 January 1853—*continued.*	Cubic Feet of Air passed through the Workings per Minute.	Cubic Feet of Fresh Air to Boiler Fires.	Total Cubic Feet of Air passed through the Shaft.
12th. With furnace, two boiler fires, 18 steam-jets, and steam blowing off at 60 lbs. per square inch; at 7. 15 p.m.	61,746	33,930	95,676
13th. Same as No. 12, but with less fresh air admitted to the boiler fires; at 7. 45 p.m.	58,762	21,600	80,362

[To face page 79.]


Upcast Shaft 10 Feet Diameter.
Joseph Dickinson
Inspector of Coal Mines
1853
Sketch of the Steam Jet Apparatus and New Furnace, as applied at the Pemberton Pits, Ince Hall, Wigan.
Scale 3 Feet to an Inch.
36 Feet
6 Feet
17 Feet
Furnace
3 ft. 6 in.
2 ft. 7 in.
Furnace
5 Feet 6 inches.
1 ft. 3 in.
6 Feet
1 ft. 5 in.
Zinc Cylinders
6 Feet long by 1 Foot Diameter
16 ¾ Inch Diameter
3 Inch PIPE
3 Inch PIPE
At present only 10 of the Jets are in use.
Jets and Cylinders

Nº 691. Ordered, by The House of Commons, to be Printed, 30th June, 1853.
Henry Hansard, Printer.

ABSTRACT of EXPERIMENTS at the CANNEL PITS, INCE HALL COLLIERY, 13 January 1853.

	Cubic Feet per Minute.
Maximum effect produced with one furnace, 6 feet across the bars, as in No. 10 experiment; total air passed through the workings -	51,466
Maximum effect produced with 18 steam-jets, 2 boiler fires, and the steam blowing of at 60 lbs.; boilers, each 40 feet long by 5 feet diameter; total air passed through the workings, as in No. 3 experiment - - - - - - - - - - -	50,872
Difference in favour of one 6-feet furnace, as compared with 2 boiler fires, 18 steam-jets, and steam blowing off at the valves at 60 lbs., the boilers each 40 feet long by 5 feet diameter - - - - -	594
Maximum effect produced by the united powers of the furnace and 2 boiler fires, 18 steam-jets, and steam blowing off at 60 lbs; total air passed through the workings - - - - - - - - -	61,746

The barometer at 8 a.m., was 29·10 inches.

Ditto - 10. 20 p.m., was 29·20. inches.

"In the experiments at the Cannel Pits it will be observed that a liberal supply of fresh air to the boiler fires had the effect of materially increasing the temperature of the up-cast, and that the current of air passed through the workings was greatest when the largest amount of fresh air was supplied to the boiler fires. With 36,000 cubic feet of fresh air per minute the difference of temperature between the up-cast and the down-cast was 86°, and the amount of air passed through the workings 50,872 cubic feet per minute. With 28,400 feet of fresh air the difference of temperature was 83°, and the amount of air passed through the workings 50,794; and with the still smaller amount of 15,200 feet of fresh air the difference of temperature was reduced to 77°, and the amount of air through the workings to 41,138 cubic feet.

"The greatest velocity attained in the up-cast shaft with the furnace alone, and without allowing for expansion by rarefaction, was 1,303 feet per minute. With the addition of the expansion due to an increase of temperature from 62°, at about which the air was measured to 174°, the temperature of the up-cast, the actual velocity attained was 1,590 feet per minute; or, in other words, 1,590 cubic feet per minute was passed through each square foot of the up-cast shaft.

"STEAM-JET and FURNACE VENTILATION, at the Pemberton Pits, Ince Hall Colliery, near *Wigan*.

"In these pits, two seams of coal are worked with a pair of shafts, one seam lies at 214, and the other at 187 yards from the surface; the shafts are each 10 feet diameter, one being the up-cast and the other the downcast. The ordinary ventilating power consists of two boiler fires, placed in the lower seam, called the Pemberton five-feet seam, and a small furnace, together with an arrangement of 10 steam-jets (as shown on Sketch) placed in the upper or Pemberton four-feet seam, the jets being fed with steam from the boilers in the lower seam. The jets were added in September last, and they are only intended to be used when the furnace is out, or at nights when the engine is not at work; the boilers are each 20 feet long, by five feet diameter, with direct or flash flues underneath. There are three main splits of air in the four-feet seam, two of the splits being about 2,000 yards each, and the other about 1,000 yards in length; in the five-feet seam there are also three main splits, of the respective lengths of about 2,000, 1,000, and 600 yards. The first series of experiments was made on the 9th December 1852; the second series on the 20th January 1853, some improvements having in the mean time been made in the arrangements:—

Vide annexed Sketch.

Pemberton Pits, Ince Hall Colliery. First Series of Experiments, with Boiler Fires, Steam-Jets and Furnace. 9 December 1852.	Temperature of Up-cast Shaft, Eight Yards from Surface.	Temperature of Down-cast.	Difference between Temperature of Up-cast and and Down-cast.	Cubic Feet of Air passed through Five Feet Workings per Minute.	Cubic Feet of Air passed through Four Feet Workings per Minute.	Total Cubic Feet of Air per Minute passed through both Workings.
1st. With two boiler fires, and the steam blowing off at 50 lbs.; average of two experiments -	135°	46°	89°	13,380	17,100	30,480
2d. With nine of the steam-jets at work, in addition to the boiler fires, and the steam blowing off at 50 lbs.; average of two experiments - -	148°	48°	100°	20,700	18,540	39,240
Increase by the nine jets, and by an increase of 11 degrees of temperature -	- - -	- - -	- - -	7,320	1,440	8,760
3d. With furnace five feet across the bars, in addition to boiler fires, and steam blowing off, but without the jets; average of two experiments - -	190°	44°	146°	17,625	20,160	37,785
Increase by the furnace -	- - -	- - -	- - -	4,245	3,060	7,305

"In these experiments, a large scale of fresh air which was not measured was passed through the engine house, in the four-feet seam. The arrangements of the pit did not admit of more than about 12,000 cubic feet of air per minute being passed through the furnace.

Pemberton Pits, Ince Hall Colliery. Second Series of Experiments, with Boiler Fires, Steam-Jets, and Furnace. 20 January 1853.	Temperature of Up-cast.	Temperature of Down-cast.	Difference of Temperature between Up-cast and Down-cast.	Air passed through Five Feet Workings, per Minute.	Air passed through Four Feet Workings per Minute.	Total Cubic Feet of Air passed through both Workings, per Minute.
1st. With the two boiler fires low, and no steam blowing off	122°	50°	72°	12,990	20,472	33,462
2d. With good fires under boilers, and steam blowing off at the safety-valves, at 50 lbs. -	150°	50°	100°	17,760	24,840	42,600
Increase by the steam blowing off, and 28 degrees of temperature - - -	- - -	- - -	- - -	4,770	4,368	9,138
3d. With 10 steam-jets in addition to the boiler fires, and the steam blowing off at 50 lbs. -	151°	49°	102°	21,015	23,400	44,415
Increase by the propulsive force of the steam, and two degrees of temperature - - - - -	- - -	- - -	- - -	3,255	decrease 1,440	1,815
4th. With 10 jets, as in No. 3, but with air-splits differently arranged - - - - -	160°	49°	111°	22,800	not taken.	
Increase by the propulsive force of the jets, and 11 degrees of temperature, as compared with No. 2 -	- - -	- - -	- - -	5,040	not taken.	
5th. With 10 jets, as in No. 3. and 4 experiments, but with increased area for the air in the 4 feet to pass into the shaft -	152°	48°	104°	21,960	24,840	46,800
Increase by the propulsive force of the jets, and four degrees of temperature, as compared with No. 2 -	- - -	- - -	- - -	4,200	equal -	4,200

On

On the completion of the above experiments at 2 h. 10 m., the boiler fires were slacked. The steam had been got down, and the jets stopped at 2 h. 40 m. At 2 h. 50 m. the furnace, which, since the first series of experiments in December, had been increased to 5 ft. 5 in. across the bars, was lighted. It should be stated, that in consequence of the proximity of the furnace to the shaft, in which were wooden guides, it was found unsafe to drive the furnace hard, and only a small quantity of air was consequently passed through it. At 6 p.m. the following experiment was taken:

Pemberton Pits, Ince Hall Colliery. Second Series of Experiments, with Boiler Fires, Steam-Jets, and Furnace. 20 January 1853.	Temperature of Up-cast.	Temperature of Down-cast.	Difference of Temperature between Up-cast and Down-cast.	Air passed through Five Feet Workings, per Minute.	Air passed through Four Feet Workings, per Minute.	Total Cubic Feet of Air passed through both Workings, per Minute.
6th. With 5 ft. 5 in. furnace, small fire, the boiler fires being entirely out - - - -	143°	43°	100°	17,670	24,960	42,630
As compared with No. 2 experiment, the difference between the temperatures of the up-cast and down-cast, is in each case 100°, and the amount of air obtained almost identically the same.						
7th. With the furnace, as in No. 6, but with less air passed through the furnace - - - -	143°	41°	102°	17,010	24,360	41,370
The barometer, during these experiments, was at 29·20 at 8 a. m., and at 29·45 at 11 p. m.						

"It appears that throughout these Ince Hall experiments, both with the furnace, boiler fires, and steam, increased temperature in the up-cast has been followed very closely by an increased amount of air. There appears, however, to be a small amount gained by propulsion. The largest increase on the application of the jets, as in No. 3 experiment in the second series at the Cannel Pits was 9,831 cubic feet per minute; this was due to an increased temperature between the up-cast and down-cast of 17 degrees, and, to some extent, to propulsion also. That some amount is due to propulsion is however perhaps more apparent in a comparison of Nos. 2 and 6 with Nos. 3 and 5 in the second series of experiments at the Pemberton Pits. In No. 2, the boiler fires, with steam blowing off at the valves at 50 lbs. per square inch, but not propulsively applied, gave 42,600 cubic feet of air per minute; and No. 6, with a like difference of 100° of temperature, with the furnace, gave 42,630 cubic feet, being a difference in the two experiments of only 30 feet. Comparing these results, which, with the exception of the lighter gravity of the steam, are due exclusively to temperature, with Nos. 3 and 5 experiments, with the steam applied propulsively through the jets, it will be seen that an increase of only two degrees of additional temperature in the one case gave an increase of 1,785 cubic feet of air per minute, and of 4° in the other gave an increase of 4,179 cubic feet per minute; being a ratio of increase in the quantity of air obtained at the rate of about 1,000 cubic feet for one degree of temperature, which exceeds the ratio due to temperature alone as compared with the other experiments. No. 3 experiment, with two boiler fires, steam and steam blowing off at the valves, with a temperature of 102°, gave 44,415 cubic feet, whilst No. 7, with the same temperature, by the furnace, produced 41,370 cubic feet, leaving a balance of 3,045 cubic feet due to propulsion, which is the utmost amount assignable to propulsion in these experiments, a comparison with No. 6 and other experiments giving a less amount.

"The quantity of coals used in the boiler fires at the Pemberton Pits is stated at 4 tons 16 cwt. per 24 hours, which, at the rate of 46,800 cubic feet of

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air per minute, as obtained by the jets and boiler fires, gives 6,268 cubic feet of air per lb. of coals.

"The furnace at the Pemberton Pits is a new one, 5 feet 5 inches across the bars, and the quantity of coals which it consumes had not been ascertained when I made these experiments; but it stands on the site of an old furnace which was 5 feet across the bars, and as it stands within 12 yards of the shaft in which are wooden guides, which are liable to catch fire, the furnace could not be safely driven hard; the consumption of coals therefore would probably be much the same as in the old one. This amount is stated at two tons per 24 hours, but allowing 10 cwt. extra as an ample margin for the slight increase in the size of the furnace, say 50 cwt. per 24 hours. This, at the rate of 42,630 cubic feet of air per minute, as in No. 6 experiment, gives 10,962 cubic feet of air per lb. of coals as the result of furnace ventilation.

"In the Cannel Pits the quantity of coals used in the boiler-fires is stated at 6 cwt. per hour, or 7 tons 4 cwt. per 24 hours, to keep the steam at 50 lbs. pressure per square inch, which is the usual pressure. The second series of experiments which gave the best results were taken with a pressure of 60 lbs., to obtain which the consumption of coals would be increased in a proportion. As this increase was not ascertained, the balance may be thrown to the favour of the jets, and the coal estimated as for 50 lbs. pressure, which gives 4,542 cubic feet of air passed through the workings per lb. of coals consumed in the boiler-fires. The furnace is stated to consume about 6 tons per 24 hours, which gives 5,514 cubic feet of air per lb. of coals. The united powers of the furnace, boiler-fires, and steam-jets gives 3,007 cubic feet of air per lb. of coals."

1110. In that case was the same proportion of fresh air blowing over the boiler fires?—The quantity of fresh air sent over the boiler fires had a material effect in increasing and diminishing the quantity of air through the workings; but this amount which I have stated as being due to the steam-jets is the maximum effect of all the experiments.

1111. Mr. *Stephenson.*] Did you compare the consumption of fuel in that small furnace as compared with that consumed with the two boilers?—The quantity used by the boiler fires in the Cannel Pits is stated as six hundred weight per hour, or seven tons four hundred weight in 24 hours, to keep the steam at 50 pounds pressure per square inch, which is the usual pressure.

1112. Have you given the consumption of coal per hour upon the furnace, or the boilers?—Upon the boilers.

1113. What is the consumption per hour upon the furnace?—I should also explain that the quantity of coal stated for the boiler fires is to keep the steam at 50 lbs. pressure, but the experiments with the jets were taken with the steam at 60 lbs. pressure.

1114. Give that 50 lbs. then?—The coal estimated as for 50 lbs. pressure, gives 4,542 cubic feet of air passed through the workings per pound of coals consumed in the boiler fires. The furnace is stated to consume about 6 tons per 24 hours, which gives 5,514 cubic feet of air per pound of coals; the united powers of the furnace, boiler fires, and steam-jets, gave 3,007 cubic feet of air per pound of coals.

1115. You say the united power of the furnace, the steam-jet, and the boilers; had you ever them united?—Yes, we tried all the powers together.

1116. Had you not the consumption per hour, of fuel, under the boilers for driving the steam-jet only?—I have not. The pressure was raised to 60 lbs. at Mr. Darlington's request, and the consumption of coals was not taken; the quantity given is for working the boilers at the ordinary pressure, 50 lbs.

1117. You have given me the consumption of the furnace alone at seven tons a day?—That is for the boilers' fires, 7 tons 4 cwt.

1118. How much does the single furnace consume, the open furnace?—About six tons.

1119. They are about equal; that is not a very great disparity?—Taking the quantity, the two boiler fires and steam-jets give 4,542 cubic feet of air per pound of coals. The single furnace gave 5,514; and the united power of the furnace and the boiler fires, and the steam-jets, gave 3,007 cubic feet per pound of coals.

1120. You do not appear to me now to have separated the effect of the steam-

steam-jet from other influences, because you have stopped the steam-jet and compared it with the furnaces; but you omit to take away the effect due upon the ventilation from the steam-boiler furnaces, because when the steam-jet is at work the steam-boiler furnaces are assisting in the ventilation?—The boiler fires are in addition.

1121. Is the effect that you state to be produced by the steam-jet alone, really, in point of fact, the effect of the steam-jet plus the coal consumed under the steam-boilers?—Yes; and with the exception of the first day's experiments at the Cannel pits, when anomalous results were obtained, every increase of air has been simultaneous with increased temperature.

1122. Does the heated air which passes through the steam-boiler furnaces go into the up-cast shaft or not?—It does.

1123. Let us suppose for a moment the steam-jet could be taken out of the shaft, and put into some other place where it would have no influence on the ventilation, what effect would the furnaces under the boiler have in producing ventilation; consuming as much fuel as they do, would they not nearly produce as much as a simple furnace of six foot square?—Yes, they would produce nearly the same result as we have obtained by the steam-jets with these fires, the only difference would be a trifling amount by propulsion.

1124. *Chairman.*] Did you ever try the steam-jet, worked with the boilers being on the surface, the steam carried down to the bottom of the pit, and the jet at the bottom of the pit?—Yes; I have seen different applications in that way. In one instance I saw it so applied at the Bentgrange Colliery, at Oldham, where the effects upon the ventilation were trifling indeed; and at the time this jet was at work the whole of the pit continued in an explosive state.

1125. Mr. *Stephenson.*] The ventilating power was small?—Very small; it is a case that I have alluded to in my report to the Secretary of State.

1126. *Chairman.*] Then, taking the whole of these experiments into consideration, your opinion appears to be that the mechanical power of the steam-jet, without any rarefaction whatever, is a very small aid in ventilating a pit?—Yes, that is my opinion; I was formerly disposed to attribute more power to propulsion, but I now believe it to be very small.

1127. Mr. *Cayley.*] According to the evidence you have given, you consider the steam-jet is a retardation rather than an assistance to ventilation?—No, that is not my opinion; I think that some amount of power is due to propulsion, but that the amount is small.

1128. The furnace, you stated, consumed six tons of coal per day?—Yes.

1129. That gives 50,000 cubic feet of air per minute?—It gave 51,466 cubic feet of air per minute.

1130. And the boilers use seven tons per day?—Six hundred weight per hour, that is 7 tons 4 cwt., to work the boilers at 50 lbs. pressure; with the boilers at 60 lbs. pressure the maximum effect produced with 18 steam-jets, two boiler fires, and the steam blowing off at the valves was 50,872 cubic feet of air per minute.

1131. Is it your opinion that the same quantity of coal would give more ventilation burned in a furnace than under a boiler?—It is my opinion.

1132. Is it your opinion, then, that the furnace alone gives the greater power of ventilation, and is greater than the same quantity of fire plus the steam jet?—Yes; I think the furnace more economical; the combustion is much more perfect in the furnace than it is under the boiler fires, that is, in a properly constructed furnace; and there is no dense cloud of black smoke rolling up the pit; the heat is not taken up by the water and flues, and the upcast is easier raised to a high temperature.

1133. Then you consider the steam-jet to be a retardation to the ventilation?—No; I think the same amount of coal applied through the furnace would give you a greater amount of air than that quantity of coal burnt under the boiler fires, however the steam generated in these boilers might be applied.

1134. Is not that a question very much of the depth of the mine?—I am speaking now of experiments made under similar circumstances in the same pit.

1135. The deeper the pit, in point of fact, the more economical does the furnace system of ventilation become?—No doubt of it.

1136. Do you think the furnaces would equally apply to shallow as to deep pits?—The furnace is not so peculiarly applicable to shallow pits as to deep ones.

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1137. Was Mr. Darlington with you when you made your experiments?—He was, and took all the figures down.

1138. Was he satisfied with the propriety of your mode of carrying on the experiments?—Yes; he made no objection to it.

1139. Was he satisfied with the results you came to, that they were correct?—I cannot say whether he was satisfied or not; we took the measurements with the utmost fairness; there was no partiality to either one side or the other; my sole object was to develope the utmost resources of the jet and the furnaces, and I believe Mr. Darlington was actuated by the same desire; the underlooker of the pit was also there.

1140. *Chairman.*] With regard to the steam-jet, although your opinion is that the furnace is infinitely superior as a ventilator to the steam-jet, can you, or not, conceive circumstances in which the steam-jet may be useful, in cases of mines being on fire; we have evidence in 1852 that the steam-jet was there applied to force carbonic acid gas down into the mine to put the fire out; do you conceive the steam-jet may be made useful in a case of that kind?—I think we know it to be very useful in cases of that kind. The case which I have given (question 1095), as an illustration of the peculiar power of the jet, had reference to one of these experiments of Mr. Gurney's, where he was forcing the choke-damp into the mine. It was this choke-damp, although it had undergone the cooling process, which had heated the down-cast shaft to 103 degrees above the temperature of the up-cast; and yet the jet was able, by acting through a confined tube, to resist that balance of temperature. I do not know any other power that could have been applied so well adapted to an experiment of that kind. But for the transmission of large quantities of air through coal mines, it does not appear to be sufficiently powerful unless applied in conjunction with temperature.

1141. Mr. *Locke.*] Was that application of the jet in any way similar to the application to the mine in Seaton Delaval?—No; that was a peculiar application, applied for the purpose of forcing choke-damp into the mine, with a view to extinguishing the fire that was in the same.

1142. I want to know whether the use of the tube was applicable solely for the purpose of forcing choke-damp, or might it not be employed, as in the case of Seaton Delaval, if necessary?—A series of cylinders might be applied at Seaton Delaval; and I think, by a series of cylinders, that is, one cylinder to each jet, the propulsive power would be increased to some extent. In those experiments which I have put in, all the jets were acting through cylinders.

1143. *Chairman.*] In explosions very often, or generally, are more lives lost by the after-damp than by the actual explosions themselves; is that so?—It varies. In my district the greater proportion of lives have been lost by burns and violence; and few by suffocation.

1144. Where it is so, do you think that the steam-jet could be successfully applied from the top of the pit to force down atmospheric air to combine with the choke-damp, so as to prevent the men from losing their lives?—Any power that you can apply readily is the best in cases of that kind. Perhaps, if a steam-jet were kept in reserve at the top of the pit, it might be an addition in such circumstances.

1145. In that case, the furnace at the bottom of the up-cast shaft would be totally ineffective?—The furnace is sometimes blown to pieces by the explosion.

1146. Therefore, although you give us your opinion that the steam-jet is not so good a ventilator as the furnace, still you think it would be advantageous, in pits where a great quantity of fire-damp existed, to have in reserve a steam-jet at the top of the pit, which could always be ready if cases of that kind should occur in the pit?—Although I am not an advocate for the steam-jet, or mechanical appliances in preference to the furnace for ventilating coal mines, there are circumstances under which economy should not be considered; for instance, with a very shallow up-cast, or where large bodies of gas have to be moved, in newly tapping a very fiery seam, where the gas is given off so rapidly that you cannot put the furnaces into it; in cases of this description, mechanical appliances are and may be resorted to successfully.

1147. The steam-jet might always be put at the top of the pit, with scarcely any expense to the coal proprietor, inasmuch as there is always an engine at the top of the pit, and the steam from its boilers could be turned into the steam-

jet

jet at any time when it was needed; is that so?—Yes; the expense would not be very great.

1148. Mr. *Locke.*] Do you consider that that would be the best mode of applying the steam-jet?—No, I do not; I think if you applied it at the top of a pit, without enclosing it into a tube, its effect would be very trifling indeed.

1149. *Chairman.*] Whatever your opinion may be as to the ventilating power either of the furnace or the steam-jet, unless the capacity and size of the air-ways is attended to, either of those powers may be very much deteriorated?—It is impossible to transmit a large amount of air through a colliery unless you have spacious air-ways.

1150. Then the actual forcing or throwing a current of air into the pit would have no effect at all, unless great and proper attention was paid to the size of the air-ways?—It is a most important point to have spacious air-ways; in fact, the ventilating power may be said to be almost useless if you have not proper space for the air to be passed through.

1151. Is it your opinion that the goaf should be cleared of foul air or not?—It is very desirable that it should be thoroughly cleared. I have stated, in a former part of my evidence, that where the goaf is foul, if there is any insurmountable difficulty in the way of thoroughly ventilating it, I think it is better not to attempt to do it.

1152. Can you give the Committee any idea of the areas of air-ways you would require? It would depend on a certain number of men working in the pit: how much air would you require for each man working in the pit?—It depends very much on the quantity of gas you have to contend with in the mine.

1153. Supposing the air-ways were sufficiently large, and supposing there was a sufficiently ventilating power in the pit, would there not then be very considerable skill required in order to force that air to every part of the pit, so as to give each workman his necessary proportion of air?—Yes, there is very great skill required. There is nothing in which the judgment of a colliery manager is more shown than in the proper distribution of air.

1154. Do you find that properly attended to in your district?—In the best managed collieries it is; in the majority of cases it is not.

1155. The air is not split?—Both in the splitting and in the proper distribution of the air to the different parts of the workings it might be improved.

1156. The consequence is, that the air passes from one part of the workings to the other, and of course the last man who breathes it, breathes air very considerably loaded with foul air, with carbonic and other deleterious gases?—He does, and what is more frequently neglected is the leakage through the stoppings; many of the stoppings, instead of being built with bricks or stone and mortar, are built with rubbish, which subsides and leaves an opening at the top, and air leaks over that; and it is not unusual to find a large quantity of air going down the down-cast and up the up-cast, but by leakage at doors and stoppings, only a very small portion of it reaches the extremities of the workings, where it is most required.

1157. Can you state what quantity of air is necessary for the supply of each man?—In the ventilation of a fiery mine, I look more to what will thoroughly ventilate the mine than to the requirement of the men per man; because what is sufficient for the thorough ventilation of a fiery mine is always more than adequate for health.

1158. But in cases where men are breathing deleterious gases, or a body of gas breathed by other men, do you not conceive that would be very injurious to their health?—No doubt it would.

1159. Mr. *Locke.*] That does not often arise in collieries, air that is already respired; have you found in mines that any deaths arising from respired air have occurred?—Yes, a few deaths have taken place from such causes, but the amount of sudden deaths from that cause is trifling compared with the injury it causes to health. I have a table here of the ventilation of a number of collieries in my district, and the amount of air in some of these is so small that it would not support a single lighted candle in the mine; it was necessary to have two or three candles put together to maintain a light; others are very large; in the smallest cases there was no ventilating power applied.

[*The Witness handed in the following Table:*]

DATE.	NAME OF COLLIERY.	VENTILATING POWER.	Water Guage in Inches.	Total Cubic Feet of Air passing through the Workings.	Number of Cubic Feet of Air obtained per lb. of Coals Consumed.
1852:					
12 July -	South Mostyn, Flintshire -	-- Furnace on surface; air-way impassable.	- -	665	—
	Ditto, 24th January 1853 -	Large fan; airway improved -	- -	5,170	1,956
13 „ -	Mostyn New Pits, Flintshire -	Temporary furnace - - -	- -	5,580	—
29 „ -	Coleshill - - - ditto -	Small furnace - - -	- -	2,640	—
30 „ -	Bath - - - - ditto -	None; air-way impassable -	- -	44	—
4 August -	Norley Hall, Lancashire -	Draft furnace - - -	- -	25,600	—
12 „ -	Laffak - - ditto - -	Large furnace on surface -	- -	17,500	—
21 „ -	Westminster, Denbighshire -	Struve's air-pump - - -	- -	23,608	5,233
31 „ -	Blackley Hurst, Lancashire, Seneley Green Pit.	Furnace - - - -	- -	8,652	7,413
2 September	Blackley-hurst, Lancashire, Little Delf Pits.	ditto - - - - - -	- -	4,763	10,206
9 „ -	Bredbury Black Mine, Cheshire	- - Underground boiler; fire and steam.	- -	4,266	2,576
17 „ -	Ince Hall Cannel Pits, Lancashire.	- - Two boiler fires and steam, and 6 feet furnace.	2	35,329	2,809
2 Dec. -	Ditto - - - ditto - -	ditto - ditto, air-ways improved	2	47,704	—
7 „ -	Ditto - - - ditto - -	Two boilers and jets - -	1 1/10	35,584	—
1853:					
13 January -	Ditto - - - ditto - -	- - Six feet furnace only; air-ways further improved.	- -	51,466	5,514
13 „ -	Ditto - - - ditto - -	Two boilers, fires, and jets -	- -	50,872	4,542
13 „ -	Ditto - - - ditto - -	Furnace, 2 boiler fires, and jets	- -	61,746	3,007
1852:					
8 October -	Stoneclough, Lancashire, Paddock Pit.	Fire grate - - - - -	- -	8,600	18,000
9 „ -	Ditto - - Starkie Pit -	Two ditto - - - - -	- -	13,360	13,213
9 „ -	Clifton, Lancashire, Manor Pit	Furnace - - - - -	- -	18,900	12,150
12 „ -	Glodwick, Lancashire, 250 yards deep.	None - - - - - -	- -	6,360	—
20 „ -	Bank, Lancashire (A. Gibbon's 2 feet air pit).	ditto - - - - - -	- -	1,000	—
20 „ -	New Water-gate, Lancashire, two pipes 2 feet area.	ditto - - - - - -	- -	560	—
23 „ -	Worsley, Lancashire, Sanderson's Pits.	Furnace - - - - -	- -	2,835	6,156
29 „ -	Kirkless Hall, Lancashire, Arley Pits.	Two small furnaces - -	8/10	59,145	38,021
7 November	Haigh, Lancashire, Bridge Pits	Temporary furnace - - -	- -	24,335	17,380
1853:					
April -	Ditto - - - ditto - -	Large furnace - - - -	- -	60,000	—
1852:					
3 November	Ditto - - - Patchcroft Pits	Two furnaces - - - -	- -	18,391	—
12 „ -	Winstanley, Lancashire, 4 feet mine.	Small furnace - - - -	- -	5,400	17,357
24 „ -	Broadfield, Lancashire, through a pipe 1 2/3 feet area.	- - Pipe inserted into engine chimney, into which the steam was discharged.	- -	850	—
9 October -	Ince Hall Pemberton Pits -	Two boiler fires and steam jets -	- -	39,240	—
9 „ -	Ditto - - - ditto - -	Five feet furnace - - -	- -	37,785	—
1853:					
20 January -	Ditto - - - ditto - -	Two boiler fires and steam jets -	- -	46,800	6,268
20 „ -	Ditto - - - ditto - -	5 ft. 5 in. furnace - - -	- -	42,630	10,962
	Orrel, Lancashire - - -	- - Eight feet furnace and one boiler fire.	- -	47,200	—

1160. *Chairman.*] In such cases as we have been alluding to, in bad collieries, or collieries where there is no gas, men breathe worse air than in what you call fiery mines?—Yes, very much so; the fiery mines are generally much more healthy than the choke-damp mines.

1161. The reason of that is, that it is necessary to split the air, so as to throw a large proportion of air through the mine, so as to clear the mine of foul air?—Yes, better ventilation is the cause of it.

1162. Do you think that any stated quantity of air to be given to a man could be enforced by legislation?—It would be very desirable if you could ensure all these mines being ventilated in some way, so, at all events, that the man should have a respirable atmosphere to breathe; whether that may be the best test or not, I am not prepared to offer an opinion; it is a very complicated question, and if enforced by law may lead to great hardships in some cases. In no case ought the men to be allowed to work, where there is not sufficient air to support a candle burning freely.

1163. Mr. *Bruce.*] That would be different in different places; either the Legislature would have to fix the minimum, or the inspectors would have to fix the minimum in each particular pit?—As a minimum, I would not go below the quantity which would freely support the combustion of an ordinary-sized candle.

1164. Mr. *Stephenson.*] If it ever reaches that point, or nearly that point, the men would not obtain light to work with?—They would not, and you would be surprised at the number of places where I hear, "This drift was holed in the dark; we had such a man who worked there; he is a capital fellow for such work."

1165. *Chairman.*] That is a system that ought not to be tolerated?—It ought not.

1166. Should not the inspector have the power to see that a proper proportion of fresh air is carried into the mine?—If any minimum amount could be fixed it would be very desirable to do so. In coal mines men generally receive higher wages for doing work of that kind.

1167. Mr. *Stephenson.*] Is it not inevitable that, when a man is holeing in the stall system, is it not necessary that he must work for some time in bad air; how is it possible to avoid that?—In the most fiery fire-damp mines, in Lancashire, it is necessary to have the air bratticed up to within two or three yards of the face of the works.

1168. Of the holeings?—Yes; I mean in the fast ends.

1169. Do you know many collieries worked where they have to brattice up the holeings to within two yards of the face?—In several of the new openings, in what is called the Arley or the Little Delf seam, it is necessary to brattice within two or three yards of the faces.

1170. In the stalls or the holeings?—In cases where the narrow work is driven to the extremities, and no stalls worked until the levels have reached their extremities; when the stalls are driven, and the pillars following after them towards the pit; in winning out these narrow levels it is necessary to brattice the air close up to the face, but after they have been driven for a time the gas pines off.

1171. *Chairman.*] These are peculiar cases, are they not; in ordinary cases, with proper attention, it is quite easy to split the air, and carry it to different parts of the workings; also to give each man his proper quota of fresh air?—Yes; these are cases that apply to the most fiery mines, which bear a small proportion to the moderately fiery and unfiery mines, where there is no difficulty in splitting the air and carrying on the ventilation.

1172. In addition to supplying the mine with fresh air, is it not easier to get the air through the mine with less power if it is properly split?—In a large colliery it is indispensably necessary to split the air.

1173. If it were not so split, it would have to travel through so many miles in the working; and the friction would be so great, and the drag of the mine would almost counteract the power of the furnaces altogether?—It would. It is very well understood by almost every manager of a large colliery; but many of the managers of small collieries, where the amount of air is small, prefer carrying the air round in one body, and they are very much prejudiced against splitting the air; but it is only among the managers who have not had the experience of a large colliery, and who do not know the difficulty of getting a large quantity of air through the workings.

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1174. When the air is properly split, the usual plan adopted is to turn the air by doors?—Yes; where you wish to carry the traffic across the ventilation, doors are used. Crossings may be sometimes substituted.

1175. In case of explosion in one part of the mine, these doors are apt to be blown away, and the consequence is, the whole of the ventilation of the mine ceases?—Yes; it is so after a severe explosion.

1176. Do you think it would be well to have such stoppings as would be strong enough to resist the power of the severest explosions that take place in the mine?—Yes; all the principal stoppings which carry the air into the mines should be made as strong as possible, with the view of preventing their being blown down by the blast.

1177. Mr. *Stephenson.*] They are very often made with brick masonry?—Yes, in the best-managed mines; but too often with rubbish.

1178. *Chairman.*] In the report of the Committee of 1852, it recommends that bore-holes should be sunk down from the surface into the goafs, so as to allow holes for the pent-up gas to escape; is it practicable to keep those holes open?—Yes; I think it would be practicable to keep them open, but I do not think you would introduce it into practice; you would not get any colliery manager to do such a thing.

1179. Mr. *Stephenson.*] Did you ever see a bore-hole under such circumstances?—I have seen a bore-hole put down to ventilate the level.

1180. What did you get, air or water?—Both; but that was the whole of the ventilation in the mine; that was done as the up-cast pit.

1181. If a bore-hole was put down to the goaf with a view of taking away the hydrogen gas, would it not be a down-cast instantly; it would fail altogether in the object in view; it would be full of water, and there would be no current of fresh air coming in at the top?—It is highly probable, if you had a ventilating power applied at the up-cast, that the bore-hole would be a down-cast, not an up-cast.

1182. Mr. *Cayley.*] Suppose a steam-jet applied to the top of the bore?—I think you would make it an up-cast by putting the steam-jet to it.

1183. Mr. *Stephenson.*] Do you think that a hole put down into the goaf of a mine is at all likely to carry away one item of the foul air of the men; would you put a steam-jet into it, or not?—I think if you put a hole down the mine, if there is any ventilation going on, it would have the tendency to carry away some of the gas.

1184. In sinking coal mines, in nine times out of ten, or probably ninety-nine out of a hundred, they have water to contend with, have they not?—Very frequently.

1185. Therefore, in boring a small hole down into the goaf of a coal mine, would the sides of that hole not yield a very large quantity of water?—It probably might; but I have stated already that the objection to putting these bore-holes down would be so great in practice, that you would not get any colliery manager to adopt them.

1186. Mr. *Cayley.*] Is there any means whereby you know ventilation is going on during your absence, between your visits of inspection?—No; we have no means of knowing.

1187. Could you suggest any means whereby you might know what amount of ventilation had been going on in your absence?—With the great number of pits we have at work in this country, it would be impossible to keep such a control over the management of collieries as that, unless you have as many inspectors as you have got managers of collieries. The great point that should be looked to, in my opinion, is to get competent managers, and merely to have the inspectors to find out, if possible, where incompetent men are employed, and also to make very diligent inquiry into every cause of accident that has taken place; and with such a code of regulations as I have stated, I think very beneficial results might be produced.

1188. There is no instrument that would practically measure the amount of ventilation going on?—None. Byram's anemometer will measure about a fortnight, but it would take an inspector to each large colliery to read off the numerous measurements that would be necessary.

1189. *Chairman.*] Do you not think that it would be impossible for the overman of the pit, if he were so inclined, to contract the current where the anemometer is placed, so as to make the air rush past it with greater force, and so deceive

deceive the inspector, if he was to make a periodical visit of once a week?—It would be quite possible for the overlooker to do so. That is not the worst effect I am afraid it would have on the managers of the collieries; by shortening the currents, and not carrying the air to the extremities of the workings where it is most required, he would increase the quantity of air passing over the anemometer, therefore, unless you had such an endless number of anemometers, probably a hundred in a large colliery, so as to measure each of those currents in its subdivided form, the result would be very defective.

1190. Supposing you had these hundred anemometers that you speak of, could not the overman deceive the inspector at each of those anemometers by contracting the current at each of these anemometers, and making it rush by them faster than the actual speed at which air travels through the mine?—He could, by placing a plank or any temporary material in the air-way, so as to contract it, deceive the inspector.

1191. *Chairman.*] However good or excellent the anemometer is, it has always that effect, that if it is in the hands of a man who would play tricks with it, the inspector could always be deceived?—He could; and besides that, it is necessary to have anemometers made so delicate, with a view of getting rid of friction, that I do not think that the anemometer in its present form, or in a form which would work with any reasonable amount of friction, would last above six months, if so long, if kept continually going.

1192. Mr. *Cayley.*] What is your principal objection, your scepticism as to the perfection of the instrument, or as to the power of preventing its being tampered with, supposing it to be perfect for its purpose?—My principal objection is neither of these two; my principal objection is, that it would induce, or have a tendency to induce, the colliery manager to shorten his currents, and consequently to reduce the quantity in the long splits, and to send a larger quantity of air over the anemometer, and not to take the air to the extremities of the workings, where it was most required.

1193. That would be one mode of tampering with the anemometer?—It would be tampering with the ventilation.

1194. Supposing you had an anemometer placed in a down-cast, or at the bottom of a down-cast, or in the air-way between the down-cast and the up-cast, and also, in addition to that, an anemometer at the extreme working, would not this be a test of the current, and of the amount of ventilation going on in the extreme working, as well as in the more direct air-way?—Before you get the air to the extremity of the works, it is generally subdivided into a certain number of large currents, and then again into a larger number of smaller currents. To ascertain what quantity of air is going to the extremities of the working it is necessary to have an innumerable number of anemometers.

1195. Would it not be some test of the circulation of the mine, supposing the instrument to be perfect for the purpose, of the amount of circulation going on at the extremity of the mine, if there was an anemometer placed there?—It is a test that I should not rely on. Indeed the current of air at the extremities of the collieries, where the air is so subdivided into so many small splits, the velocity is so slow that it would not move Byram's anemometer. Many of Byram's anemometers will not move under a velocity of 120 feet per minute; it is a very delicate one indeed that will move at 50 or 60, and that current is seldom obtained in the extremities of the workings; therefore your anemometer, in a drift that was sufficiently ventilated, you might remain stationary.

1196. Would that amount be sufficient for health; would there be a sufficient ventilation if the current did not move the anemometer?—In many cases it would, supposing the drift near the extremities of the working, 50 feet area, and you have a velocity of, say, 70 feet per minute; that would be 3,500 feet of air per minute for the ventilation of that working alone, which is very much more than is generally sent to each separate working at the extremity of a colliery.

1197. I thought you said that Byram's anemometer was a very delicate instrument?—I stated that it was necessary to have it made as delicate as possible, with a view to getting over friction; but with all this care which has been bestowed upon it, I know of no instrument where the friction is less than 50 feet per minute, and in some cases it is more than 120; that is, that it requires a current of more than 120 feet per minute before the instrument will begin to move.

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1198. Do you ever use the anemometer yourself?—I do.

1199. When you visit the mines?—Yes.

1200. If you trust yourself to an anemometer, when you are inspecting a mine, to know the actual ventilation, if there could be an anemometer devised which registered the amount of the current, why should not that tell its own tale on your next visit if it could not be tampered with?—For the reasons I have stated at such great length.

1201. A registering anemometer, in point of fact, is, in other words, the same instrument which you use to test the amount of ventilation when you visit a mine, with a registering apparatus attached, which denotes at your next visit the amount of ventilation going on in your absence?—Yes.

1202. Then if it could not be tampered with, why should it not speak the same truth in your absence as in your presence?—I think it could be tampered with; and if you make it register beyond a fortnight you would multiply the number of wheels to such an extent as to increase the friction considerably more.

1203. You are now expressing a doubt as to the anemometer doing the work which it professes to do?—That is only one doubt; but I have expressed my objection to such a system of check being kept over the managers, and the most important reason was not to any defect or any want of reliance upon the instrument, but that it would have a tendency to induce the manager to send a larger quantity of air through the short splits, and to diminish the quantity in the long ones, which would increase the total quantity as registered by the anemometer.

1204. Supposing there were scientific means devised by which those attempts to tamper with truth could be defeated, would your objection to some extent cease?—You might have a large amount of air going down the down-cast, and up the up-cast, and over your anemometer; but there might still be a number of places in your mine which would be quite sufficient to blow the whole mine up; therefore, as a practical man, I should place no reliance whatever on these records of the anememoter.

1205. You would prefer to have no test at all to having a test of a certain definite value?—I think if your test cannot be in having the managers to take an interest in ventilating the extreme points of the mines, you had better have no test at all; you would make it then their interest to neglect the points which require most attention, and by too much attention to matters of secondary importance you direct attention from the main point, and conduce to the very thing you are endeavouring to avoid.

1206. What is the objection to having one anemometer at the very extreme point of the working of the mine?—It would be merely a record of the air at that one place; that is, provided there were sufficient air to move it; but it would not be a record of the other places which are of equal importance, and which are very numerous.

1207. It would not be a record of the distribution of the air near the extreme workings?—No; and you might have a large quantity of air circulating along this drift where the anemometer was placed, but there might be a fast end going out of that drift up which no air was passing, and which might be sufficient to contain enough fire-damp to blow all the men up in the place.

1208. It would tend materially to the proper supply of air in all the extreme workings, if there was an ample supply of air at the very extreme working?—I think if you made it a colliery manager's interest to throw a large amount of air over his anemometer, you would, from the circumstances I have pointed out, tend to diminish the supply of air to the extreme points where it is most required. I do not think any practical man would place any reliance on such a test as your question appears to propose.

1209. Mr. *Baird.*] Do you consider the best test of a well-managed colliery to be the absence of accidents?—Not invariably; as a general rule, it is so; but a colliery under strict discipline may go on being very badly ventilated for some time, until at last the evil day comes, and there is an explosion. As a general rule, it is the very best test in the absence of inspection.

Jovis, 23° die Junii, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Baird.
Mr. Cayley.	Mr. Fitzroy.
Mr. Ingham.	Mr. Locke.
Mr. Hussey Vivian.	Mr. Farrer.
Mr. H. A. Bruce.	Mr. Mostyn.

E. J. HUTCHINS, Esq., IN THE CHAIR.

Joseph Dickinson, Esq., called in; and further Examined.

1210. *Chairman.*] YOU stated in your evidence that every old pit should be properly fenced off to prevent persons falling into it; are there not nearly as many accidents occurring in winding persons up and down the pits?—Yes, a great number of accidents take place in winding people up and down pits.

1211. From what cause do those accidents principally arise?—From a variety of causes; in some cases from boys or men tumbling off the cage, or more frequently from the skip; sometimes from a man incautiously putting his head out, and getting it crushed against the cross trees.

1212. Do accidents of that character arise from their own carelessness?—Where there are guides in the pit they generally arise from want of caution on the part of the men; but in pits where there are no guides, and only a loose skip, the men are sometimes thrown off by the two skips coming in collision, by the ascending skip coming in collision with the descending one, and throwing the men off, or by its striking against the side, and throwing the men off.

1213. Do you think, therefore, it should be enforced by legislation that every pit should have guides to it?—As far as practicable to enforce it. There are some cases in Staffordshire and Denbighshire, where the portion of coal which has to be worked is so small, that there is not sufficient coal to be left for a proper shaft pillar; indeed the whole portion of coal to be worked is only the size of an ordinary shaft pillar. In that case, you cannot prevent the shaft squeezing and bulging out of shape. Wooden conductors, under such circumstances might be displaced, and be unsafe for the cage to run upon; but wire ropes might be applied to meet these cases, which would obviate the evil.

1214. As guides?—Yes.

1215. My question did not allude to wooden guides; but to guides of any kind or sort; your answer alluded to pits which were entirely without guides?—I think guides should be enjoined as far as possible; I do not know of any case where they could not be introduced. The Staffordshire people make an objection to the introduction of guides, for the reason I have stated. I also know of a case in Staffordshire where the landlord of the property has objected to the introduction of guides, when the tenant has introduced them.

1216. What reason did the landlord assign for objecting to the introduction of guides?—He said the use of guides had a tendency to lead the colliers to break the coal smaller, to put it into the trains, and produce a larger proportion of small coal.

1217. Mr. *Farrer.*] Why should that be?—I think it is only a prejudice; I see no reason for it whatever. The tub, in this case, where it has been introduced, carries about 30 hundred weight of coal, and there is ample space for putting in any ordinary lump of coal, such as one or two men could lift.

1218. *Chairman.*] In the case you have described just now, where the shaft has got into a dangerous condition, and such a condition that they could not use guides, do you think such a pit is safe for men to be wound up and down?

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—Very unsafe; they are called crooked pits, and they are not fit for men to be drawn up and down; it is only in the Staffordshire district and Denbighshire where such a thing is known.

1219. In your opinion, then, should not the pit be kept in such a condition at all times that men could be wound up and down with perfect safety by legislative enactment?—At the present moment there is no practical objection that occurs to me to prevent the use of guides being compulsory in every case where men are drawn up and down; in the sinking of pits it is seldom desirable to have guides; they are only used in working pits, except in very rare cases, where they are used in sinking deep pits.

1220. During the process of sinking?—I should certainly not make them compulsory in that case.

1221. Mr. *Farrer.*] Would the use of guides secure the men against accidental collision when the skips are one ascending and the other descending?—They would.

1222. Mr. *Baird.*] Would not a brattice have the same effect?—Certainly, not so good; it is possible to make a brattice in such a shape that it acts as a sort of guide for the skips; the addition of a rod on the brattice would be a very slight expense indeed.

1223. *Chairman.*] But the use of guides in pits would not necessarily render the pits so safe that the men would be free from danger from the falling of the sides of the pit?—Certainly not.

1224. Could you recommend any plan by which the pits could be rendered perfectly safe?—In the code of regulations I have put in, I have stated what precautions I would take for guarding against such accidents.

1225. Do you consider that casing the pit from the top to the bottom would be an effectual remedy against parts of the pit falling down and killing men in their descent?—It is an effectual remedy, and one that has been taken in my district in the best managed collieries. The manager of the largest colliery in the district was very strongly opposed to walling his pits throughout. After a number of recommendations, and a long correspondence with him on the subject, he has at last assured me that every new pit should be walled. He represents the largest colliery in Lancashire, where 1,500 men are employed.

1226. Would this increase the expense of sinking the mine?—It is a very trifling addition to the expense of sinking. I think in the long run it would be a saving; there is generally time lost in the repair of sides of shafts, and which has to be done at a busy time, when the use of the shaft cannot be spared for such a purpose.

1227. Does it not happen that accidents frequently occur by which men are killed by pieces of coal falling from one ascending bucket, while the men are descending in the empty one?—It does sometimes happen, and also by materials falling from the top of the pit.

1228. Do you think that the Legislature should interfere to prevent the men being let down the pit while the materials are coming up?—Yes; I think it is a regulation which would meet with the approval of the majority of experienced mining engineers in my district.

1229. Would that cause a very great hinderance in the pits where a very large amount of coal was brought up every day?—No, I do not see that it would.

1230. Could accidents be obviated by any apparatus that has yet been brought out, such as Fourdrinier's?—I have already stated my opinion to be, that I place much more reliance on having good tackle and good winding arrangements, han I do upon any arrangement for arresting the cage in the event of a breakage taking place. I think if we had all our pits fitted up with Fourdrinier's apparatus, or an apparatus which is an improvement of Fourdrinier's apparatus, by White and Grant, it would be better. If that apparatus were attached to every working pit in our country, we should have the ropes worked very much closer than they are now, and instead of a decrease of accidents, we should have a positive increase by the breakage of rope, and a new source of accident would be introduced in the complication of the apparatus.

1231. Is it not the duty of an inspector now to see that the machinery and apparatus connected with the pit are in proper order?—It is a part of his duty.

1232. In the course of your inspection, have you ever represented to the owner

owner of a colliery that any part of the machinery of his pit or ropes were in improper order?—Yes, I have, in several cases.

1233. In consequence of your representations, has he taken any means to obviate the danger that existed?—Yes; in a great number of cases; I could quote one which took place.

1234. Did you ever find any case of their non-compliance, or refusing to comply with your suggestions?—We have sometimes a difficulty in persuading them that we are correct in our views, but I have generally succeeded in the end.

1235. Provided they did not comply, and any accident was to take place, there would be no remedy at law against those parties so neglecting their duty?—If we had an opportunity of attending at the inquest we should attend, and state to the coroner and jury that we had pointed these dangers out to the colliery manager, and he did not appear to have taken the precautions which we stated to be necessary. We have not always an opportunity of attending at the inquests; many of the inquests are held before we hear of the accident.

1236. But in cases of that kind, would you feel it your duty, if possible, so to attend, and to represent to the coroner those facts which you have stated?—Yes.

1237. What time do you think ought to elapse under ordinary circumstances before the coroner's inquest sits over the body; in order to give you time to attend the inquest in all cases, what would be the average necessary time?—In answering that question we have to consider that the body cannot be kept above a certain time, and that the coroner and jury must assemble for the purpose of viewing it; 48 hours is the time allowed now, and I believe that could not be extended.

1238. Has not the coroner now the power to adjourn the inquest; could not he assemble the jury and view the body, and adjourn the inquest to a future day, when you could attend and give evidence as to the cause of the accident?—He has that power; but it gives rise to a great number of complaints on the part of the jurors, that they are obliged to meet twice and receive no pay for their services. The coroner in some districts is allowed double expenses for holding an adjourned inquest; in other cases he is only allowed the expenses of a single inquest. In the majority of cases the jurors receive no pay whatever.

1239. Do you consider that the law, as regards coroners' inquests in that respect, is not in a proper state?—I think it admits of improvements.

1240. Do you know the practice of Scotland with regard to accidental deaths in mines?—Yes.

1241. When an accident occurs, the owner of a mine is immediately obliged to write to the Lord Advocate, apprising him of the accident; he then sends to the inspector, desiring him to report on that accident to the procurator-fiscal?—Yes.

1242. And the procurator-fiscal, after receiving the report, lays it before the Crown counsel, who decides whether a prosecution shall take place or not; is that the state of the law?—Yes, that is an outline of it; the police also make their own inquiries with respect to the accident; they have a sort of secret system at work, and they ferret out information from sources which they know. This is also laid before the procurator-fiscal; and if on this evidence, which has been furnished by the police and others, if they think there is a case to prosecute, they prosecute. Having been a manager of a colliery in Scotland, I know what is the feeling of the managers on the subject. Fortunately, I never had a fatal accident during the time I was there, therefore I have not experienced it personally; but my own feeling on the subject is so strong, that I would rather manage a colliery for 100 *l.* a year less in England than in Scotland; the rather than have to undergo the excitement which the manager is placed under at the time the secret inquiry is taking place with regard to the accident.

1243. You say the police are the parties who make this secret inquiry?—It is part of their duty.

1244. What police do you allude to; is it the county police?—The constables of the district.

1245. Do you think that the system pursued in collieries in Scotland renders the owners and managers of collieries more careful?—I have no doubt it has that

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effect, but I think it is carried to an extreme in Scotland; men become really nervous under it.

1246. Do you not think that improvements might be made in the law of Scotland and England, so as to assimilate them, and put them both on a better footing?—Yes, I do not know of any objection to it.

1247. Mr. *Ingham.*] Supposing an inquest is held before you have an opportunity of attending, and you are aware that in the colliery where the death had occurred you had previously given directions to have greater precautions used, would you think it your duty to communicate with the Home Office?—If I had served a colliery owner with a formal notice, I should consider it my duty to do so.

1248. Whether you had been at the inquest or not?—Yes; a case occurred in my district, where I had a colliery owner, not exactly under formal notice, but he had undertaken to carry out certain suggestions which I had made to him, which obviated the necessity of serving a formal notice on him. An explosion of fire-damp took place in the colliery afterwards, and immediately on receiving information of that accident, I posted off to the inquest. That was before I received any official information of the accident, but I found I was too late, for I met the coroner coming away. In that case I had a long interview with the manager, and told him it was my intention to bring it before the magistrates; but his promises of amendment were so strong that I did not do so.

1249. Mr. *Baird.*] Are you aware now that all the expenses in England, of prosecutions at the assizes, are defrayed by the Treasury and not by the county?—I am not aware of that.

1250. That being the case, would there be any difficulty in the proper authorities of the Government, if they thought it right, directing that a Crown prosecution should take place on your report, although the coroner's inquest had not returned a verdict justifying such a course?—I very much doubt whether the Home Office would have authorised a prosecution in the case. We generally find, where loss of life is brought in as manslaughter, and that is sent to the assizes, in nine cases out of ten the case is thrown out, by the judge stating that it is a case that falls within the proper degree of caution and culpable neglect. Two such cases of that kind have occurred in my district in this present year, but both were thrown out by the judge and jury upon that ground.

1251. Mr. *Ingham.*] Are you aware that in either of those cases there had been specific directions given by the inspector which had been neglected or contravened by the proprietor?—They were both cases which appeared to be combined with considerable neglect. I was present at both of the inquests. I had previously examined the colliery in one case; but they were neither of them cases that the inspector could have any control over. One was the case of an engineer drawing the cage up to the pulley; the other was the case of a collier not setting sufficient pit wood to support the roof of the workings, and sending his drawer under it to fill the coal.

1252. *Chairman.*] What was the coroner's verdict in the first case?—Manslaughter.

1253. Mr. *Ingham.*] Had you, before that, observed anything in the conduct of this engineer to make you think he was an improper person to be placed in a situation of trust?—I had not seen the engineer before.

1254. You had not at all represented to the proprietor of the mine that this particular man, in his employment, was unworthy of his situation?—I had never seen him before, and knew nothing of him; therefore I could not make such a representation.

1255. It is not such a case as I mentioned, where the act by which the party came to his death was committed by the owner, after directions to the contrary from the inspector?—It was a case which no Act could meet.

1256. That was a case in which it was the personal default of the engineer, and in no way attributable to any misconduct on the part of the proprietor?—It was, and he was severely reprimanded; the colliery proprietor stated at the inquest that the man had committed a breach of duty in having done so.

1257. Was that indictment preferred against the engineer or proprietors?—Against the engineer.

1258. *Chairman.*] And the bill was ignored?—I believe in both cases they were thrown out by the grand jury.

1259. Mr.

1259. Mr. *Vivian.*] You stated that you would recommend that men and materials should not be wound up together in the same pit?—Yes, I did.

1260. Does your objection apply to such pits as are not properly fitted with guides and cages?—It applies to all cases where there is a brattice partition between the two cages, and it also applies to the winding of the coal up any other pit than the one the men may be going down. In some districts it is common to have one engine to wind from three or four pits, so that if men were going down in one pit, you would have a loaded skip coming up the other pit. You would then have the maximum strain on the machinery when materials only were being raised, which those regulations which I have proposed would avoid.

1261. That might apply to that particular case, but such a case is not common in the coal trade?—No, it is only common in the Staffordshire district.

1262. *Chairman.*] The cases you would apply that to are only in ill-regulated collieries?—I should not make any exception in any case.

1263. Mr. *Vivian.*] Have you ever known accidents occur in properly fitted pits, from materials falling down while men were being wound up?—Yes; it is a very common cause of accident, and the regulation alluded to is a regulation at many pits at the present time. In my district it is a common regulation; you may not have it in South Wales, where the regulations are much more lax.

1264. I did not know that such a regulation existed in the northern pits?—In some it may not; it is much more common in Lancashire.

1265. Mr. *Locke.*] Does it not extensively prevail, both in the counties of Durham and Northumberland, that they do not wind up coals at the same time that men are ascending and descending where the shafts are not bratticed; is it not a general rule that men are not permitted to go up and down the shafts while they are pulling coals in pits that are not bratticed?—As a general rule, men do not go up and down against loaded tubs; and where I meet with it in practice, I always make a representation as to the danger attending it, and in no case have I not succeeded in receiving an assurance that it should not be continued for the future.

1266. Mr. *Vivian.*] Do you conceive the danger to arise from the unequal strain on the machinery, or the falling of the material?—Partly from the one and partly from the other; when the winding engines are very powerful and in good order, there is comparatively little if any danger from the breakage of machinery; but in the Staffordshire district, where heavy three-linked chains are used, and the machinery much weaker, there is very great danger.

1267. That I can easily conceive; but in collieries fitted up in the best style would it be desirable to apply such a regulation?—I think it would; it would inflict no hardships upon them, as the men all go down together in the morning. It does not apply to the coming up, where only two pits are used, as the empty tub would be coming down. It is only in the case where the pit is in full work during the day, that it could be considered a hardship, and at such times it is only overmen or the viewer who is going down.

1268. *Chairman.*] The falling of these materials does not depend on the excellence of the machinery of the pit; supposing the coal was improperly loaded by the collier, or supposing the collier had properly loaded the coal, and that the roads at the bottom of the pit were in bad order, and however excellent the machinery was in the pit, might not the coal be shaken out by the slightest movement, and fall on the heads of the men?—A piece of coal might fall from a tub that was not well filled.

1269. Mr. *Locke.*] I understand your objection to go even to the use of the men descending in the mines where there are two pits; where a loaded tub is coming up one of the pits, you object to the men descending in the other pit where there can be nothing to fall?—The only objection in that case is as concerns the machinery.

1270. In what respect do you consider the descent of the men, going down one shaft, whilst the loaded tub was coming up the other, as putting any more strain on that machinery than the ordinary balance of the first loading, and then unloading the skips going up and down those shafts?—I should think the weight of a man is an addition.

1271. Is the weight of a man larger than the weight of the tub coming up when

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when it is in the act of ascending?—The weight of the man is in addition to that of the full tub.

1272. Would not the weight of the man descending in that tub have the effect of balancing the two?—I think the engineer would have more control over his engine if the cages were empty.

1273. Do you see any extra strain on the machinery in the case put?—Do not you think that the weight of the descending man would rather tend to balance the two loads, and give the engineer a more perfect command over his engine, than if he had a training engine pulling at one tub?—Yes, I think the engine would be better balanced; but a weak engine would be more likely to break, having the additional weight of the man in addition to the weight of the coal.

1274. You think a weak engine would be more likely to break, having less work to do?—Having the addition of the man to the coal.

1275. I am supposing a descending man against an ascending tub; I wish you to answer that question?—Suppose the drum-shaft to be weak, and both drums fixed on one shaft, I cannot give any other opinion than the one I have given. I think there would be a greater strain on the drum-shaft.

1276. You think there is more strain on the drum-shaft by the man descending than if they were not descending?—Yes.

1277. And your objection, therefore, is to the use of two pits; to the permitting the men to descend the one, while the loaded tub is ascending the other?—Where there are only two pits, and good machinery, my objection to descending the other pit is very slight.

1278. Is that one of the cases that you would insist on absolutely prohibiting, or would you make that an exception to the rule?—If that was the only cause, I should not think it necessary to prohibit.

1279. Are you of opinion that that ought to be one of the exceptions to the rule?—I think it might be an exceptional case.

1280. What would you propose to do if you had to frame a code of regulations; would you propose a positive prohibition in a case like that?—I should make the regulations as simple as possible, and with a view to avoid exceptions I should include that in the rule.

1281. Mr. *Vivian.*] Then the rule would not apply to men ascending; only to men descending?—Only to men descending.

1282. Mr. *Mostyn.*] Would you recommend the attendance of the inspector on all coroners' inquests relating to those mines under his inspection?—Certainly not, unless you made the inspector the coroner. In this country the coroner's duty is to inquire into every case of sudden death; on the Continent they have no coroners, and it is part of the inspector's duty to inquire into every colliery accident.

1283. *Chairman.*] Do you find the workmen commit reckless acts, so as to endanger the safety of other men?—Sometimes.

1284. As the law exists at present, has the magistrate the power of inflicting fines upon those workmen who so transgress?—I have stated that on that point a difference of opinion appears to prevail among the magistrates; some consider that they have power, others consider that they have not.

1285. Do you think that the law should be made clear on that subject?—I think it is very important that it should be.

1286. In what district is it that these magistrates have refused?—Mr. Vivian stated that he knew of a case where they refused to convict.

1287. Where was that?—I think it would be in South Wales.

1288. Did they refuse to hear the case, or refuse to convict because they considered that they had no power to convict; that the Act of Parliament did not give them power?—I cannot state the particulars of those cases Mr. Vivian alluded to; but in my district, a few months ago, I received a letter from one of the colliery owners, telling me he had made application to the stipendiary magistrate for the district for the purpose of prosecuting a man for leaving an air-door open, by which a serious explosion might have taken place. It is a similar misdemeanor to opening a safety-lamp. The magistrate refused to act in the case. The colliery owner asked me what he should do under the circumstances. I undertook to see the magistrate, who assured me that, if any future application of the kind were made to him, he would give it his best attention,

attention, and that he would see what the law was upon the point. He was not aware of the Act.

1289. When workmen do commit these reckless acts, so as to endanger the lives of their fellow-workmen, and those acts are discovered by any of their fellow-workmen, do they usually inform the overlooker?—Such cases do take place sometimes, but they are very rare.

1290. Do you mean that cases of carelessness are very rare?—No; where one man informs against the other is very rare indeed.

1291. Do you think a workman would be more likely to screen a man?—Yes; as a general rule, they are more likely to hide each other's faults than bring them forward.

1292. Have you read the Report of the Committee of 1852 with regard to safety lamps?—I have.

1293. Do you agree in this portion of the Report: "Your Committee would now refer to some more incidental means of security against explosion; first, stating their concurrence in the opinion expressed, directly or indirectly, by the Committees of 1835 and 1849; and also with that so strongly expressed by the South Shields Committee, that where a proper degree of ventilation does not exist in a mine, the Davy lamp, or any modification of it, must be considered rather as a lure to danger than as a perfect security. Practically secure in a still atmosphere it may be considered; and in the hands of a cautious over-man an admirable instrument for exploring, or as an indicator of danger; but in a current, as admitted by the illustrious inventor himself, it is not a security; and in the hands of an ordinary workman, under circumstances of excitement, when danger is threatened, it is not improbably, far oftener than imagined, the very cause of the explosion which it was intended to prevent?"—I agree with that generally; but at the latter end, I think it is not so frequent as they suppose it to be; I think cases where explosions have taken place through the gauze of the safety-lamp are exceedingly rare, and only two cases have come to my knowledge where such accidents have taken place.

1294. Is it your opinion that in fiery mines the use of the safety-lamp should be enforced or not?—In some mines I think it should be used.

1295. However good the ventilation?—I think that is a point that might to some extent be left to the discretion of the manager. The difficulty is in drawing the line between a fiery mine and a very fiery one; what some persons would call a very fiery one another person would call a moderately fiery one.

1296. Would you give power to the inspector to determine when the safety lamp should be used, and when it should not be used?—Yes, I think the inspector might be entrusted with that power.

1297. What are the sort of safety-lamps now in ordinary use in this country?—The common Davy lamp is the lamp generally used. Two of the North of England managers give the preference to Mr. Clanny's lamp: Mr. George Elliott and Mr. Easton. The Stephenson lamp is also becoming now much more generally used than it was; it has the property of becoming extinguished immediately on an explosion taking place, which puts it out of the power of a workman to remain in an explosive atmosphere with a light.

1298. The Stephenson lamp has glass within the wire gauze?—It has, and is fed with air from the bottom.

1299. The Clanny lamp has glass at the bottom of the lamp quite unprotected?—It has.

1300. Is it safe to use a lamp with glass so unprotected?—It is not considered safe by nearly all our mining engineers in this country, but on the Continent they consider them perfectly safe; and they place every confidence in them, and I am not aware of any accident having taken place in consequence of the glass abroad, where they are very extensively used.

1301. The glass is made very thick, is it not?—It is generally made very thick, and well annealed.

1302. However thick it might be, if the glass was to get very hot, and a drop of water was to come on it, would it not have a tendency to break that glass?—Yes.

1303. If such an occurrence were to take place to a man, and the glass were

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so to break, it would cause an explosion in the mine?—That is one of the great objections that our engineers had to them.

1304. If the lamp was in an explosive atmosphere it would go out?—Most of the glass lamps have that property.

1305. The Clanny lamp has that property?—Yes, as a general rule, the Clanny will; but it is possible to keep up an explosion in the top of the tube of the Clanny.

1306. *Chairman.*] Would the Clanny burn in an atmosphere in which, if a naked light were used, it would explode?—No; as a general rule, it would go out.

1307. Have you seen the lamp invented by Mr. Henderson?—I have not.

1308. Have you seen Dr. Glover's?—I have that here.

1309. Do you approve of the principle of Dr. Glover's lamp?—It avoids the objection to the glass lamp so far as the breakage by water goes, inasmuch as the air passing down between the two glasses has the effect of keeping the outer glass quite cool.

1310. What kind of lamp gives the best light?—The Eloin lamp.

1311. Is one of the objections by the men to the use of safety-lamps the small quantity of light that lamp gives?—Yes, that is the objection to the Davy lamp.

1312. Is it not, therefore, material to have a safety-lamp in which could be combined the most perfect security and the greatest amount of light?—It is very desirable to have such a lamp.

1313. Have you seen Dr. Fyfe's lamp?—I have; I have not had an opportunity of making any experiments with it. I heard the Doctor deliver a lecture on it; it seems to me much the same as the Clanny, with the addition of a double gauze to the top of it instead of a single gauze.

1314. Have there been any improvements made in the safety-lamp since the report of the Committee in 1852?—I think Dr. Glover's lamp has been patented since that Committee, and Dr. Fyfe's lamp has also come out since that Committee.

1315. Is Dr. Fyfe's lamp here?—It is so nearly like the Clanny, that I did not think it necessary to bring it.

1316. Do you think the improvement made by Dr. Glover renders his lamp the most safe of any lamp hitherto invented, and combining with that quality the giving the greatest amount of light?—I do not think it is more safe than the Davy or the Stephenson.

1317. Mr. *Locke.*] What in your opinion, having reference to the object of the safety-lamp, namely, the security of the mines, is the best lamp according to your knowledge?—Considering all the circumstances with reference to lamps, I am disposed to give the preference to the Davy.

1318. The Davy stands first in your estimation?—Yes.

1319. Which do you think is the next best?—The Stephenson is a good lamp for the workmen.

1320. Do you think the Stephenson better than the Clanny?—So far as avoiding the glass goes, the Stephenson has the advantage.

1321. If you were called upon to order a lamp for a particular colliery, what lamp would you order?—I should leave it to the option of the manager of the colliery, for I believe with proper care they are all safe.

1322. Then the answer you have given with respect to the Davy, is that there is no material difference between that and any of the rest?—No, a very slight difference indeed; for testing fire-damp there is no lamp so good as the Davy.

1323. *Chairman.*] Why?—You can judge of the presence of gas so much more accurately by it, and also the quantity of gas.

1324. For the purpose of working in a fiery mine, where no naked lights are allowed to be used, to which lamp would you then give the preference?—I believe them all to be safe, but I think one of the lamps which becomes extinguished on coming into an explosive atmosphere best for the working men, but the Davy for the firemen.

1325. Mr. *Farrer.*] If you could render it impossible for the miner to open his

his lamp, which would you prefer then as a locked lamp?—The best locked lamp is the recently registered lamp of Watson's, of Newcastle-on-Tyne.

1326. *Chairman.*] What is the principle of that lamp?—It has a very long key about two inches long, and you cannot open it with a nail.

1327. Is it a common Davy lamp, with a key to it?—It is both the common Davy and the common Stephenson.

1328. With Watson's improved lock to it?—Yes, and also a different arrangement as to the opening of it.

1329. Your answer applies only to the lock?—Yes.

1330. Mr. *Farrer.*] Has the miner, when in the mine, at present, a key for opening the lamp?—Where locked lamps are used, the miner is supposed not to be in possession of a key.

1331. *Chairman.*] But your opinion decidedly is, that the inspector should at all times have power to order the use of safety-lamps in a fiery mine, if he should think proper so to do?—I think he might be entrusted with that power, and that power would come under the regulation I suggested, in one of the clauses of the Act, to the effect that the inspector should be entrusted with power, in cases where imminent danger existed; where the manager refused to adopt proper measures for increasing its safety, he should have the power to order the working of the mine to cease; that is, under the restrictions which I specified.

1332. Of course you think that attention to ventilation is a primary course to pursue, in order to make a mine safe?—It is.

1333. Therefore, whether the inspector orders a safety-lamp or not, he would not pay less attention to see that the ventilation of the mine was properly carried on?—Certainly not.

1334. You would not use the lamps in order to screen the colliery proprietor from having proper ventilation, but you would rather use the safety-lamps to increase the security with the proper ventilation?—Merely for the purpose of guarding against an emergency such as an outburst of gas, or a discharge of gas. No workings should be systematically carried on in an explosive atmosphere.

1335. Therefore, you agree with the report of the Committee of 1852, that the primary mode of rendering mines secure is attention to the best mode of ventilation?—I do.

1336. Mr. *Ingham.*] You gave your opinion as to the comparative merits of lamps with respect to their safety; now, as to their illuminating power, which lamp are you inclined to prefer?—The Eloin lamp gives the best light, but it is generally attended with the disadvantage of going out in a brisk current of air.

1337. Which do you prefer of the English lamps?—The glass lamps come next; all the glass lamps, without exception, are equal. There is the Glover lamp, and the Clanny lamp, and all the glass lamps.

1338. Which of the glass lamps combine the most safety with the most illuminating power?—The addition of the chimney to Dr. Glover's lamp, as in Musileer's lamp, appears to make it safer than an ordinary Clanny.

1339. Then, as a combination, you give the preference to the Glover lamp?—For certain purposes I would, but for other purposes I would not. If you are travelling in old wastes, and a little choke-damp happens to be coming off from the waste, the Glover lamp will go out when a Clanny lamp will burn, and when a Davy lamp will burn; so that, in a case of that kind, I should prefer a Clanny.

1340. But for ordinary working purposes, where the men were hewing, you would prefer the Glover?—I think I stated that I place all these glass lamps on a par; I make no distinction between one and the other.

1341. You were understood to say that there was more safety in the Glover as a glass lamp?—It has some advantages which some of the others have not. Clanny's has not the Museleer chimney, and has only a single glass.

1342. It is not added to the Clanny now; of the actual lamps in use which do you prefer?—For a workman, I think that the Glover has that additional safety which the Clanny has not.

1343. Are you aware of the Glover lamp being in actual use in any one of the collieries in the north?—No, I am not; it has only recently come out.

1344. Do you not know the fact that it is in use at Wingate Grange and Pelton?—

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Pelton?—I know that experiments have been made by Mr. Reid, the viewer at Pelton. I believe he is satisfied with the lamp, but I am not aware that he has introduced it for the use of the mine.

1345. Are you aware that it is not a more speculative lamp, but that practical men have given consideration to it?—Experiments have been made by practical men; I am not aware whether they have introduced it for their workmen or not; I believe it is not in use anywhere in my district.

1346. Mr. *Mostyn.*] Are you acquainted with Coed Talon, in Flintshire?—I am.

1347. Is it a well-managed colliery?—No, I do not think it is, it is very roughly managed; indeed, one of the roughest in my district.

1348. When did you visit it?—I have been there two or three times.

1349. Have you been there within the last twelve months?—I have; at the time when I went down into the workings one of the pits had a flat chain in it. Since that time, there has been nothing but single link chains at the colliery. I go into no colliery where there is a single link chain, unless I have urgent business to take me there; I do not think it is safe.

1350. Were any plans shown you?—Yes, plans of all the seams excepting one.

1351. In the course of your experience you have seldom seen a worse-conducted colliery, have you?—It is very rough.

1352. And highly dangerous, as compared with your general knowledge of collieries?—I have objected to the use of single link chains there, and I have pointed out the want of plans to Mr. Harrison, the manager. He undertook to get these plans made. On going back, as I stated previously, a year afterwards, although he had undertook to have the plans made, he had not carried out that undertaking. I afterwards directed Mr. Oakley, the proprietor's attention to it. I received a letter from Mr. Oakley, informing me that he would see to it, and that it should be attended to.

1353. I understand that those instructions you gave to Mr. Harrison and Mr. Oakley, a year ago, have not been attended to?—Mr. Oakley has since promised me that he would attend to them himself, and see it was carried out. I hope he has attended to it, I have not been there since.

1354. Are you aware of the number of accidents that have taken place there?—There are a larger number than usual at that colliery, considering that it was in North Wales. The men of North Wales take great care of themselves, more than they do in other parts of my district. The mining in North Wales generally is very rough, and but for the great care the men take, the number of accidents would be very great; as it is, they are very few.

1355. Still, in the Coed Talon Colliery there have been more than the ordinary proportion of accidents?—Yes, I have taken that view of it but recently. I should not apply it. I think greater care has been exercised for some time past; and of late there has been no accident there. The last accident was by the breakage of a rope, which occurred under unfavourable circumstances.

1356. Is the Davy lamp used there generally?—No, there is not much fire-damp in the mine.

1357. Then are we to understand that the accidents which have taken place have not been in consequence of explosions, but general mismanagement of the working?—Chiefly by falling in of the roof, want of care in the timbering, and tumbling down pits, the winding arrangements being very rough indeed.

1358. *Chairman.*] Is it your opinion that any scheme could be adopted for the establishment of schools for the children of the workmen in collieries?—I think there might be such a system without inflicting any great hardship on the colliery proprietors. I believe several of the colliery proprietors have expressed themselves favourable to such a system.

1359. Do you think any system could be enforced by legislative enactment?—I think it might be; it is so in the case of the print-works; I think it might be applied to coal mines.

1360. How would you provide funds for such schools?—I think they might be made self-supporting, by deductions from the workmen's wages, as adopted with the Dowlas Colliery, with which you are conversant.

1361. That could only be done with the consent of the workmen themselves?—Yes.

1362. In almost every case, would the workman consent to a small deduction towards the establishment of schools for the education of his family?—No; I think in many cases they would object to it. There are some parts of my district where the men are very ignorant indeed; where they attach very little importance to education.

1363. Taking that as your opinion, that a great many would object, would it be wise in the Legislature to pass an enactment enforcing the establishment of schools at all collieries?—It would be very desirable if such a thing could be done; you could not get all the boys to go to school without there is such an enactment.

1364. But provided you had such an enactment, could you then force the boys to go to school?—They do it in the case of the print-works now.

1365. Will you describe the system?—I cannot give the details of the print-works system.

1366. Are you prepared to recommend any plan?—I am not.

1367. Mr. *Vivian.*] Would it be possible to prohibit the employment of any boy who could neither read nor write?—I think it would be very much opposed if such an Act were passed.

1368. Mr. *Farrer.*] Do you think it would be advisable?—I think it would not be advisable.

1369. *Chairman.*] In most of the collieries in your district, are there not funds provided for the relief of the workmen in case of sickness?—There are not in my district; there is scarcely a sick fund in connexion with any colliery; the men have benefit societies of their own.

1370. Mr. *H. A. Bruce.*] The men belong to clubs?—Many of them do.

1371. Almost universally?—Generally.

1372. Mr. *Farrer.*] Are you speaking throughout the country, or of your own district?—My own district.

1373. Mr. *Locke.*] Has it come to your knowledge, that the miners in all parts of the country belong to benefit societies or sick clubs?—As a general rule, the workmen throughout the country belong to one or more sick funds.

1374. Is it necessary or desirable that any legislative interference with the workmen, with reference to these establishments, should be made in addition to that which exists?—It is desirable that some provision should be made for the widows and orphans. I do not see how it could be done in the case of collieries alone, without having the colliery owner to pay the larger portion of poor rates than another employer in another trade. If any enactment is made with reference to coal mines, it should be general with respect to builders and railway contractors, and all classes of workmen.

1375. Are we to understand that, in your opinion, the benefit societies and sick clubs which exist at present are not sufficient to meet the case?—I do not think they are sufficient to meet the case.

1376. Do you know the extent to which they are carried?—I know they are very general.

1377. Do you know the extent of payment which the family would receive on the death of any member of it?—I do not know the utmost amount paid in such a case. I know in some cases, where a man belongs to several funds, during the time of sickness he is in receipt of more money than whilst he is at work.

1378. You know a case of that kind?—There are many such cases represented.

1379. Is that a desirable state of things?—Certainly not.

1380. Would you propose to remedy that defect in any way?—I have not considered the question sufficiently.

1381. You were understood to say that the present system was inefficient; to what extent do you consider it inefficient?—I have stated with respect to widows and children, it is very desirable that some provision should be made for them, and also in the case of an accident happening to a workman; but if such provision were made compulsory by law, the Act should apply to all trades, and not to coal mining only. Respectable workmen have a great objection to receiving parish relief.

1382. Do you know whether the present system of the benefit societies, as they now exist, does not meet those cases?—To a great extent it does.

1383. Are you prepared to say it is so far deficient that it is necessary to make any other enactment whatever; and if so, to what extent?—I think an

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enactment might be made upon the point, but that it should include all trades, and that coal-mining should be merely one of them all. To make an enactment for coal-miners alone would come into collision with the poor rates to a great extent. If any enactment should take place, it should apply to trades generally.

1384. Still you do not know to what extent those casualties are not met by the present system of benefit clubs and sick clubs?—I know in cases of accident, and in cases of death, that many of the relatives, and the sufferer himself, is sometimes left in a state of very great distress, and he is thrown on the parish or the sympathy of his friends.

1385. You also said you have known cases where persons have belonged to so many institutions of that kind that they have been in receipt of more wages than when at work?—Yes.

1386. Those two opinions being given to this Committee, what is the best mode of obviating those two extreme cases; are there not cases that lie within those two extremes?—No doubt, a very large number.

1387. Does not the general number of cases attending those institutions lie between those two extremes?—A great number; perhaps the majority.

1388. Mr. *Cayley*.] What are the payments to the benefit clubs in the colliery districts, as compared with the payments in agricultural districts; what higher premiums do they pay?—I can tell you what the payments are in the colliery districts. I do not know what they are in the agricultural districts; fourpence in the pound is a deduction which is sometimes made from workmen's wages at the collieries; that includes a penny halfpenny for doctor, a halfpenny for schools, and twopence for sick fund.

1389. Is that per week?—That is per pound of the workman's earnings.

1390. *Chairman*.] Then the doctor attends him while he is sick, and he pays to the doctor only when he is well and at work; is that so?—It is; and for that he is entitled to medical relief; in many cases the wife and family are not attended for that payment but in the best organised cases the wife and family, or any one dependent upon the man is attended.

1391. Where do the first cases exist?—I should think they are the majority.

1392. Where the man alone is attended, and the wife and family are not attended?—Yes, I think they form the majority.

1393. Mr. *Cayley*.] Taking the case of the support of a man after the age of 60, under the circumstances of the possibility of his being cut off before that time, the insurance for him would be very small; but supposing it affected his wife and the support of his children, is there any instance where benefit societies would have to contribute to the support of the wife and children that you remember the rate of contribution to?—I do not recollect a case of the kind to give you.

1394. In reference to the support of the widow and family after death, you do not recollect any case?—I do not; that is one of the cases where I say there is great suffering.

1395. The benefit societies do not extend to such cases?—No.

1396. Mr. *Baird*.] There is no annual payment after the decease of the husband?—No.

1397. Mr. *Cayley*.] Do you consider that it is material to the safety of the workmen working in various pits that the traps should be carefully attended to?—No doubt of it.

1398. Would that be as safely confided to the care of a boy as to the care of a man?—There is a difficulty in getting men to do such work as that; it is not thought to be men's work. Some viewers state they more frequently find an old man asleep, than they find a boy neglecting his duty.

1399. What is your own experience?—The cases where men are put to doors are so few that I can scarcely offer an opinion upon the question; I have, in a critical case, where there has been a very important door to keep, put a man to attend to it.

1400. Have you experience of an accident having been produced by the carelessness of the person to whom the care of a trap has been confided?—The recent explosion in the Arley Pits, at Ince Hall, was supposed to have arisen from the fact of a door having been left wide open, but there was no evidence to show that such was the case; and all the evidence that bore on the subject showed that the doors had been shut up to a very short period before the accident.

1401. Mr. *Locke.*] Are you prepared to recommend that boys should not be employed?—I am not prepared to make such a recommendation. I think unless you get boys into pits when young, you would never be able to keep up a proper staff of colliers. It is dirty laborious work, which no man of mature years would think of commencing.

1402. *Chairman.*] In Scotland, it is constantly the practice for the widows and orphans of men who have been killed in collieries to bring actions against the owners of mines where the husbands or fathers have been killed by gross carelessness, and damages are constantly given by juries; do you think such a law would be applicable to England, and, in your opinion, should such a law be enacted?—I believe the same law does apply to England.

1403. Mr. *H. A. Bruce.*] Can you point out the superior facilities in Scotland for the widows and orphans of colliers killed by accident recovering damages from the owners or managers of collieries?—I am not aware that there are any peculiar facilities in that respect in Scotland. There is a procurator fiscal, but in a civil action I think the party would have to proceed himself. They proceed, I believe, under Lord Campbell's Act; and I know no other reason for our men here not entering such actions, but that they are not generally so well informed as to the law; and I think a better feeling exists between the master and the men. In the case of a serious accident there is generally some relief, and a subscription is got up, and the parties are relieved to some extent, which keeps up a good feeling. Then the children or relatives of the deceased might imagine that their interests would be affected to some extent, if proceedings were taken by them to recover damages against the colliery owner.

1404. Mr. *Fitzroy.*] Has any instance occurred of an action being brought against the colliery owner, or the manager of a mine?—I have heard of one at Wakefield, but I cannot give the particulars.

1405. Mr. *Ingham.*] Are your answers as to the provisions made for the families of the deceased confined to your present district, or are you speaking generally?—Generally.

1406. Is it not the practice in Northumberland and Durham, that the widow is permitted to have a free house and coal free for the rest of her life?—In some cases it is.

1407. Is not that the general practice?—I cannot say it is general.

1408. Do you know any colliery where it does not prevail that, when a man has lost his life by accident, the widow is not allowed to continue in his house and have her coals free during her life?—I cannot give you a case in Northumberland or Durham, but I can in other parts of the country.

1409. Do you know enough of the district to give an opinion upon the subject?—Yes, I know the district very well.

1410. Is it not, as far as you know, the universal practice?—I am not prepared to say whether it is universal or not.

1411. *Chairman.*] Could you give the Committee any estimate of the amount of expense that a colliery owner would be put to in cases of severe accidents or severe explosions?—They are very various.

1412. Are they not put to very great expense, in cases of serious accidents by explosions?—Almost invariably.

1413. Looking at that fact, is it not the interest of the coal owner to keep his mines in as good a state as he possibly can?—It is his interest to keep them in the best state possible, but they not unfrequently take a short-sighted view of the matter, and in endeavouring to economise and get the coal cheaply, proper precaution is not taken, and an accident takes place.

Herbert Francis Mackworth, Esq., called in; and further Examined.

1414. *Chairman.*] YOU have heard Mr. Dickinson describe the ventilation in Belgium?—I can describe to you the ventilation in several collieries there.

1415. Perhaps you will do so?—The general system of ventilating collieries in Belgium is to allow the air to descend the winding-pit to the lowest part of the seams then in work. These seams are almost invariably highly inclined. The air on entering the seam is divided into two parts, which pass right and left; the currents pass to the extremity of the work up the face, and return again by the level which has served for extracting the coal in the working on

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the next higher level. The air is then conducted by a cross-measure drift, ordinarily into the shaft, which is used for the men to ascend and descend by ladders. As an example, in the Grand Bac Pit, near Liege, the air is split 10 times, each passing one face of work. The average length of the current in the mine is 2,200 yards; each division of the air averages 2,000 cubic feet per minute. The ventilation was carried on by a chimney 220 feet high, and nine feet in diameter, without any furnace. When the weather becomes warm in the spring a ventilator of Lesoinne's construction is set in motion, which produces a ventilation of 19,000 cubic feet of air at a water gauge of one half-inch.

1416. Under ordinary circumstances is there no artificial power?—During the winter months the ventilation is carried on by this chimney without artificial power.

1417. You heard Mr. Dickinson's evidence as to the mode of ventilation in Belgium being principally conducted by mechanical means?—Yes.

1418. Do you agree with him as to the one machine which he named being the best?—Fabrey's pneumatic wheels, that is the best ventilating machine they have in Belgium.

1419. Is that as good as Mr. Struve's machine?—It gives about the same economical result as the first machine of Mr. Struve, which was erected at the Eagle Bush Colliery, and which of course possesses many imperfections since remedied.

1420. Mechanical ventilation of that kind is not practised in England?—No, there is an unfounded prejudice existing against it, on account of its imagined liability of derangement, and possibly causing an explosion.

1421. Are you in favour of a mechanical ventilation, comparing it with the furnace and the steam-jet?—Ordinarily speaking, I recommend the adoption of a furnace in mines, principally on account of its convenience, and because it is in the majority of cases sufficiently effective in producing ventilation. But there are numerous collieries in my district which cannot have a sufficient amount of air passed through them by furnace ventilation; and in other instances on account of the condition of the shafts, the employment of furnace ventilation would be comparatively far more expensive.

1422. Have you seen anything in Belgium with respect to ventilation that is better than it is in England, that you would recommend to be adopted?—Many things.

1423. What are they?—There are a number of ventilating powers employed there, nearly every one of which possesses a peculiar merit, and I think the knowledge of the performance of these ventilators would be very useful in this country, because they might be adopted with advantage in many of the English collieries which now require such powers to ventilate them.

1424. State what they are?—Motte's pneumatic screw; Letoret's inclined vane fan; Lesoinne's windwill ventilator; Pasquet's spiral ventilator, Fabrey's pneumatic wheels, the cylinder and piston pumping engine constructed of wood; Lemielle's feathering fan, and others.

1425. Mr. *Locke.*] These are all the machines which you think are useful, and that you would recommend in this country?—There are certain cases in which one or other of them would be more applicable than the other.

1426. *Chairman.*] Are they all applicable to ventilation?—Yes, they are all applied to ventilation in Belgium, and the best are considered more certain, powerful, and economical than the furnace.

1427. Mr. *Fitzroy.*] In addition to the furnace, or alone?—Alone; the furnace is considered to be less economical, and is forbidden by law in fire-damp collieries, and even associated with dumb-drifts, is being abandoned in order to be replaced by ventilators. Some of the first engineers on the continent have devoted themselves to this subject; the opinion in Belgium is unanimous, and in a country where the slightest danger is carefully avoided, not the slightest fear is entertained of a ventilator breaking down or danger arising from it.

1428. Are some of these more applicable to some places than others, or are they generally applicable to the English mines?—Some are applicable to a large ventilation with a small drag, others to a smaller ventilation with a heavier drag.

1429. But all capable of being adopted in this country?—Yes.

1430. Can you recommend them all equally, or have you any preference for any particular system?—I have experiments on each which will point out their peculiarities.

1431. *Chairman.*]

1431. *Chairman.*] You will put in those experiments?—Yes.*

1432. Mr. *H. A. Bruce.*] Are any of those plans adopted in England?—Some modifications of them; there are several kinds of fans used, and Struve's ventilator is a great improvement on the plunging bell ventilator used in Belgium.

1433. Mr. *Locke.*] What do you mean by the same kind of ventilator used in Belgium?—Struve's ventilator is an airometer similar to the gas-meter, moving up and down in water; the form in Belgium is only single acting, the air is admitted underneath, and passes out underneath; whereas Struve's performs the same office above as well as below the airometer, by four sets of valves.

1434. *Chairman.*] You have a table of the experiments of the relative value of these machines?—I have.

1435. Put that in?—Yes.

1436. Looking at the whole question of ventilation, is it your opinion that ventilation is carried on better in England than in Belgium?—The amounts of ventilation are larger in the well-managed collieries in England than they are in Belgium, but the means by which the amount of ventilation is obtained in Belgium are, in some cases, better than in England.

1437. You do not agree with the Report of the Committee of 1852 with respect to mechanical powers generally?—No, I think mechanical ventilation is very much overlooked in this country, and I think it is one of the most economical powers there is; its economy and its effects have been well ascertained, and I think it ought to be introduced into many collieries.

1438. Do you think it preferable to the system of ventilation by rarefaction?—I am prepared to compare one of the best ventilated collieries in the north of England, in an economical point of view, with the first of Struve's ventilators which was erected.

1439. Mr. *H. A. Bruce.*] Can the same amount of ventilation be procured by the invention you have mentioned as by the system now practised in England?—Yes, I believe so, by one or other of the Belgian ventilators; and by Struve's ventilation, I believe, the largest amount of ventilation can be obtained that circulates through any colliery in England. I will give you a few details with respect to one of the largest collieries in the North of England ventilated by the furnace, to form an economical comparison between the ventilation of that and of the Eagle's Bush Colliery, where the first of Struve's ventilators was erected; the Tyne Main Colliery was lately experimented upon by Mr. Nicholas Wood in the most careful maner, and it is from his data that I give the economical position of the ventilation of the colliery.

1440. How is that ventilated, by furnaces?—Ventilated by two furnaces, each six feet four inches wide; the consumption of fuel was 16·76 pounds per minute.

1441. Mr. *Locke.*] Give us the quantity of air extracted?—The quantity of air was 101,876 cubic feet per minute at a water-gauge of 0·925 inches; the amount of horse-power expended in that ventilation was 14·88.

1442. *Chairman.*] You consider that a very good result?—Yes; each pound of coal consumed on the furnace therefore produced a useful effect of 0·88 horse-power.

1443. What was the depth of the shaft?—672 feet; 8 feet in diameter, and a portion of it 7½ feet in diameter.

1444. What is the cost?—I have taken the consumption of coal, 3,942 tons at 3 *s.* a ton, which gives 591 *l.* 6 *s.* per annum. Four firemen at 14 *s.* a week, each would give 145 *l.* 12 *s.*; maintenance 6 *l.*; total 742 *l.* 18 *s.* The annual cost, therefore, per horse-power of effective ventilation was 50 *l.* The first cost of the two furnaces was about 350 *l.* The upcast shaft, 1,344 *l.*

1445. Does that include the sinking?—Yes; I have put it at the lowest estimate, for which any such shaft could be sunk, less than the real cost.

1446. A brick shaft?—Yes; and they had to pass through water, but I was desirous of putting it in the most favourable light, the total first cost was 1,694 *l.* The first cost, therefore, per horse-power of effective ventilation is 114 *l.* I might mention that the natural ventilation of the Tyne Main Colliery, before the furnaces were set to work, was 34,955 cubic feet per minute.

1447. Of natural ventilation?—Yes; but I give that entirely in to the effect of the furnaces, because there was no natural ventilation at the Eagle's Bush

Vide Appendix.

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Colliery. The temperature of the external air being high, and the upcast shaft only 16 feet deep.

1448. Mr. *Locke.*] Was there any chimney producing that natural ventilation in this case?—The shaft was the chimney; that was the natural ventilation through the colliery. At the Eagle's Bush Colliery the ventilation is produced by two airometers, each of 113 square feet area. The speed of the airometers was 75 lineal feet per minute. The engine had a 2 feet 9 inch stroke, and 8 inch cylinder. The boiler 9 feet long, 4 feet diameter; cylindrical, round ends, and steam at a pressure of 40 pounds. The consumption of coal 93 pounds per hour. The amount of ventilation 16,950 cubic feet per minute.

1449. That is against the 101,000 before?—Yes; the water-gauge was 1·55 inches, the horse-power expended in effective ventilation was therefore 4·14, or 2·67 effective horse-power per pound of coals. That is the point to which I have brought the calculations to form the economical comparison. The result of Tyne Main Colliery was 0·88 horse-power to a pound of coals, and at Eagle's Bush Colliery it was 2·67.

1450. Mr. *H. A. Bruce.*] Three times as great?—Yes; the cost of airometers, masonry, and connexion with the mine was 300 *l.*; the cost of the boiler, engine, and engine-house was 200 *l.* The consumption of coal 310 tons, at 3*s.*, 46 *l.* 10 *s.* per annum. The wages of two boys 52 *l.* Grease and oil 6 *l.* 12 *s.* I have taken interest on capital and repairs there at 10 per cent., 50 *l.* Total annual cost 155 *l.* 2 *s.*

1451. Mr. *Locke.*] In the capital account you have no shaft sinking?—The shaft is only 16 feet deep, that is included in the cost of the connecting with the mine.

1452. What mine is this; is it the Eagle's Bush?—Yes; similar to many other collieries in South Wales, the coal is worked very near to the surface.

1453. *Chairman.*] You gave us the cost per horse-power in the first case; what is the cost in this case per horse-power?—£. 25 8 *s.* is the annual cost of working per effective horse-power, and 120 *l.* 16 *s.* is the first cost per effective horse-power.

Vide Appendix.

1454. You will put tables of these two experiments in?—Yes.

1455. Mr. *Vivian.*] In instituting this comparison, you included the cost of the shaft in one case, and not in the other?—The cost is included in both. At Eagle's Bush it is included in the connecting with the colliery.

1456. Assuming that you had to ventilate the Tyne Main Colliery by Struve's ventilator, would it not be necessary to expend the same sum in sinking a shaft?—I think that at the Tyne Main Colliery I might have made use of a pumping shaft for the ventilation, if I made use of Struve's areometer, and consequently should not have sunk another shaft.

1457. Mr. *Locke.*] Are you aware that at the Tyne Main the shaft was sunk purposely for ventilation?—I am not aware of that. If mechanical ventilation were adopted, it might be converted into a winding shaft.

1458. In instituting a comparison of this kind, where you are testing two machines, do you or not think it fair to consider the working-up shaft as an element fixed in both cases?—No; because where there is a deep, large and walled shaft disposable for ventilation, I think that the furnace is the best power to employ. Where there is no shaft so disposable, except a pumping shaft, then the mechanical ventilator is the best power to employ, and in that case it is not right to include the first cost of the shaft in the cost of the ventilator, as no additional shaft is required for ventilation.

1459. In this case you have instituted a comparison wherein you have made use of a pumping shaft in the one system, and you have charged to the other system the entire cost of the up-cast shaft?—Yes, in the first cost; because the expense is actually saved to the owner; the first cost is not so important as the annual cost.

1460. *Chairman.*] In your tour in Belgium, have you seen any ventilating machinery, or any process of ventilation, which would induce you to recommend to the Legislature by enactment to enforce any particular system?—I think that the ascending ventilation should not be made altogether compulsory in collieries in England, because there are many in which there would be great difficulty, and it might be impossible to produce it. But I think that air ought never to be allowed to descend a second time in a fire-damp colliery without the exercise of very great caution, and should only be permitted by the manager

or

or the proprietor of the colliery by express directions, and under his personal inspection.

1461. Looking at all these different modes of ventilation by mechanical power, and looking at the modes adopted in England, did you see anything so superior in Belgium, as would induce you to recommend to the Legislature by legislative enactment, to enforce any particular system adopted in Belgium? —No, I think the kind of ventilating power must be left entirely to the proprietor; these ventilating powers, one or the other of them, are amply sufficient to get a proper supply of air to any colliery.

1462. This pit at Eagle's Bush; it would have been possible to put up a furnace to ventilate there?—No; before this ventilator was erected, a culvert up the slope with a chimney on the top of the hill was erected at great expense, but without producing adequate ventilation.

1463. In your opinion, the ventilation by rarefaction does depend on the depth of the up-cast shaft?—Yes, it varies as the square root of the height of the heated column, and as the square root of the difference of temperature of the up-cast and down-cast column.

1464. Mr. *Cayley.*] Would you indicate, as far as you can, the particular conditions under which you think mechanical power is preferable to furnaces in ventilating mines?—The majority of the pits in Somersetshire and Gloucestershire are of so small a diameter, averaging four or five feet, and are so nearly filled by the tub when it ascends and descends, that I think it would be imprudent often to adopt furnace ventilation. That is a case in which the mechanical ventilation is particularly applicable. When the drag of a colliery is very considerable, when it amounts to half an inch of water for shallow mines, and above an inch for deep mines; when the workings are carried on by means of levels or an inclined drift, so that but a very short up-cast column could be obtained; when a pumping shaft is available for the up-cast air when a shaft would otherwise have to be sunk for the purpose of ventilation. In up-cast shafts, which are used for winding, and where a high temperature is an objection; also in shafts which are not walled, where the expense of repairs amounts not unfrequently to 7 *l.* or 10 *l.* per month.

1465. Would you say, generally speaking, that the machine was preferable in proportion to the shallowness of the mine and the amount of the drag?—Principally.

1466. How did you test the relative value of these several ventilators in Belgium?—By the amount of ventilation, and the drag of the colliery.

1467. How did you test the amount of ventilation?—By the anemometer.

1468. Did you test it at all in the up-cast by the water-gauge?—I take the water gauge as well as the amount of ventilation.

1469. What effect was ever produced on the water-gauge by these machines? —I think about three inches is the maximum I have given in my tables; four inches has been reached with Fabrey's.

1470. If these machines were to get out of order, would not the effect be that the ventilation would be practically stopped?—With some machines it would.

1471. In any machine, would not the effect be, that if the machine were to get out of order, there would be an immediate stoppage to the ventilation?—Some machines are so applied, that the ventilation would pass through to a certain extent. Others, such as Struve's areometer, would stop the ventilation altogether, unless the valves were removed, which can easily be arranged.

1472. What power was generally applied to these ventilators?—The amount of horse-power applied to the ventilators has hardly been carried beyond 12-horse power, that is generally sufficient to ventilate Belgian mines, which are small.

1473. Was steam the power used?—By means of a steam-engine.

1474. If the machine was to get out of order, the power would then become wholly deficient?—The ventilator would stop; at Mynyddbachyglo one engine works a large ventilator, winds and pumps, so that if it breaks down the whole works must stop.

1475. And the ventilation in the mine would cease?—It would.

1476. Is there not a certain amount of friction to be overcome in all these machines?—Yes, it varies in different machines.

1477. Is that a loss of power?—A very considerable loss of power.

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1478. If you could apply the whole power of the steam to the air to be moved without the friction of machinery, would not that be a more economical application of power than by machinery?—The application of the steam-jet directly to the air, to set it in motion, would be a much more expensive application of it than applying it by means of the steam-engine.

1479. In what way; is not the high-pressure jet applied to the atmosphere?—The steam-jet is applied directly to the air, but rotatory engines, where it is so applied, have been always notoriously failures.

1480. Is it not one of the first laws of motion, that a body in motion continues to move until it is stopped by means of some body stopping it?—Theoretically, it is.

1481. How is the steam stopped?—By the reaction on all sides, as well as the line of motion, by its own weight, by its condensation.

1482. Does not the steam-jet communicate the whole of its power to the atmosphere with which it comes in contact?—I imagine that it expends a greater portion of its power on the jet through which it passes, and in forming a partial vacuum above it.

1483. Would not the power be indicated by the tendency to vacuum which it produced?—No; the water-gauge will give you a certain indication of the amount of resistance to the force applied by the steam to the air, by the expansion in the air of the mine which this force and resistance, pulling against one another, cause.

1484. If the effect of the water-guage amounted to 15 feet by the steam-jet, and the effect of the water-guage by one of these machines which you say amounted to three inches, would not show a greater power applied to the atmosphere by the steam-jet?—I think there have been most serious mistakes made in stating that the water-gauge is an indication of power; water-gauge simply indicates a resistance; what I call power is resistance multiplied by velocity; another name for it is work.

1485. Mr. *Locke.*] Do you think it would be an advantage that the steam should pass directly to the paddles of a steam-boat, instead of going through the cylinder and having its force expended through machinery in order to produce a result, or do you not?—I think it would be an enormous squandering of power.

1486. If you passed the steam directly to the paddle?—Yes, there would be an enormous loss of power if you applied the steam-jet directly. In order to determine the power of a jet of steam or any other means of moving air, it is necessary to take into consideration both the resistance, as indicated by the water-gauge, and the velocity. Although you may obtain 15 feet possibly of water-gauge by a jet, the quantity of air that passes is little or nothing at all; and to put it in the strongest light, I believe, without any difficulty, I could suck up the same amount of water-gauge with my mouth. I believe that is precisely the same action which the steam exercises; water-gauge is no indication of power at all, without it is associated with velocity.

1487. Mr. *Cayley.*] You saw the experiment in the Polytechnic Institution last year; how do you account for the force which appeared to be applied there?—There was the force applied, but there was not the power developed.

1488. The water-gauge was affected to the extent of 15 feet?—Yes, I have understood that it was, the common pump will do 30 feet.

1489. If the water-gauge was affected to the extent of 15 feet close, or nearly close to the jet, can you assign any reason why a water-gauge, placed half way up the shaft, would not be equally affected, the conditions remaining the same?—It depends entirely on the air passing, it is impossible for me to form an idea of what the power produced was when those 15 feet of water were raised by the steam-jet, without knowing the quantity of air passed through by that steam. In practice the steam-jet falls much below the furnace, and far below other powers in the water-gauge it will produce, and the resistance it will overcome. I have given a table of the cost of getting up three inches of water-gauge with a steam-jet.

1490. Mr. *Locke.*] Are we to understand that the objection to the use of mechanical means was, that it was subject to derangement; if that machine got out of order the ventilation of the mine would be entirely stopped; now apply that to the destruction of a machine by explosion, would it be as easy to re-adjust or re-apply that fixed machinery for the purpose of ventilation, as it would be

be to fix the furnace?—Your question divides itself into two parts, which I will answer consecutively. I made particular inquiries in Belgium as to their experience of these machines, and they were surprised at the idea that there should be any danger connected with the use of them, either from their breaking down, or causing explosion when they did break down. One, which had been longest in use, was a wooden cylinder and piston ventilator, a kind most liable to derangement, at the pit Hainchamp's, which had been at work for 18 years without a break down. An explosion had occurred during that time without affecting the machine. Whenever a ventilating machine is employed, in order to use every possible precaution, I think that the air-way between the ventilator and the shaft may be covered with planks, so that an explosion would blow those out without affecting the ventilator, and in that case they could be replaced more rapidly, and brought to work much more safely than a furnace.

1491. Mr. *Vivian.*] You would attach a description of safety-valve to the machine in case of explosion?—Yes.

1492. Have not the force of explosions been known to blow the whole shaft head off?—Yes.

1493. Mr. *Locke.*] In that case would your safety-valve be effectual?—Perfectly.

1494. Then with this precaution, in your judgment do you think that you would be perfectly secure from derangement by the adoption of these mechanical means, and that there would be no chance whatever of their being destroyed?—I speak simply on the information I received in Belgium, and the unanimous opinion there as to their superior safety.

1495. Supposing these mechanical means were employed in England, and liable to explosions such as we have here, do you think the application of such a machine to a mine would be perfectly secure against explosions if they arose?—I think they might be made perfectly safe. The precautions that I should adopt in a colliery where they were used in case a break down of a machine occurred, would be a strict rule that all the men should leave their work as soon as there was a stoppage in the air current. The use of a ventilator affords additional security for having a uniform current of air; for there are three very simple kinds of danger signals adapted to the ventilators in Belgium, which act through the medium of the water-gauge. As soon as the water-gauge falls a little, it sounds a whistle, and the engine-man is immediately aware that there is a slight diminution in the amount of ventilation. The water-gauge is a delicate test, because it varies as the square of the amount of ventilation.

1496. Mr. *Locke.*] Would it be difficult to apply it to furnace ventilation?—It would be necessary to have a boiler to the whistle.

1497. Would it be difficult to apply that for the purpose of giving warning?—No, it would be nearly as easy, putting out the cost of the steam-pipe, to apply it to a furnace as the ventilator.

1498. Mr. *Vivian.*] But a signal line passing from a water-guage, placed under ground, up the shaft to a whistle on any boiler at the surface, would equally indicate the fall of the water-gauge?—In that case it would have to be observed by a man; whereas, in cases to which I have been alluding they would be self-acting.

1499. Mr. *Locke.*] In either case could it not be made self-acting?—Yes, by putting up a small boiler, or other means of sounding the whistle.

1500. It being as easy in one case as the other to apply the security which you suggest as one of the peculiar advantages of the mechanical means of ventilation, do you still attach as much importance to the mechanical means as you attached previously?—Yes, I think it is a safer appliance to the ventilator, because the water-gauge in this is very much greater than the water-gauge of the furnaces, and there is a great fall for a small diminution in the ventilation.

1501. Might not they be of the same size?—Yes; the water-gauge of the furnace and the ventilator might be the same.

1502. *Chairman.*] You stated in a former part of your evidence that the mines in Belgium were by no means so fiery as the most fiery mines in the north of England?—No, they are not so fiery as the most fiery mines in the north of England.

1503. In any mines in Belgium did you find the same amount of ventilation going

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going through them as you found in some of the mines in the north of England, in Durham. Take the South Hetton, for instance?—No; the quantities of ventilation in the north of England in the larger collieries is three times as much as in the largest collieries in Belgium. The collieries in Belgium are not so large as those in England, owing very much to the direction in which the seams lie, being highly inclined. With strictly ascensional ventilation much smaller quantities of air are necessary for safety.

1504. To procure such an amount of ventilation as they have in some of the best managed collieries in the north of England, do you think any of these mechanical apparatus could be applied economically?—There is a mechanical apparatus (Struve's) now erected, and a portion of it (one airometer) is at work at the Middle Dyffryn Colliery in South Wales; and I believe when the air-ways are opened out to anything like the same extent in size as the air-ways of the collieries in the north of England, that it will produce a ventilation quite as large, and more economically.

1505. Can you state what is that apparatus?—There are two 20 feet diameter airometers of the same kind which I have described, and each stroke will produce a ventilation of 10,000 cubic feet.

1506. Is that Mr. Struve's apparatus?—Yes.

1507. Can you tell the Committee what horse-power steam-engine it takes to work those airometers?—The steam-engine at Eagle's Bush is about 8-horse power.

1508. What is this one at Dyffryn?—I have not seen it since it was put up; I think it is an 18-inch cylinder. Mr. Powell has gone to great expense to have his colliery ventilated in the best way.

1509. Is it your opinion that that machine will be worked more economically than the furnaces to produce the same amount of ventilation?—I think so.

1510. What is the depth of the mine?—The depth of the shaft is 165 yards; at present there is a furnace at the bottom, and a steam-jet on the surface; and I have no doubt of the economy being far greater than that of these motive powers, separately or combined.

1511. Mr. *Cayley.*] Is there not a point of depth at which the furnace becomes the most economical mode of ventilating?—There is a point, but I am not aware that it is yet attained by the deepest shaft we have in England.

1512. *Chairman.*] You have stated, that in your excursion through Belgium, you have found nothing which you can recommend to be adopted as an improvement in the working of the best regulated mines in England; with respect to the management, have you seen anything in Belgium that you can recommend as being a decided improvement on the best managed mines in England?—I think the discipline of the Belgian collieries is as nearly perfect as discipline can be.

1513. Has the number of deaths decreased in Belgium in the last 15 years?—Dividing the last 15 years into three periods of five, and taking the average number of deaths on 10,000 persons employed in the mines, in the first five years there were 208; in the second five years 170; in the third and last five years, up to 1850, 120.

1514. Have you seen experiments made on the steam-jet in Belgium?—I have an account of them.

1515. Mr. *Ingham.*] Were you present at the experiments?—No.

1516. *Chairman.*] From whom did you receive them?—From Mr. Glepin, who was appointed by a large colliery proprietor to compare the various known ventilating powers, with the view of introducing the most economical in his very extensive works at Grand Hornu; he is the engineer of those collieries.

1517. Mr. *Locke.*] Not a Government engineer?—No.

1518. A civil engineer?—Yes.

1519. Are his experiments published?—They are printed only for private circulation.

1520. *Chairman.*] Did you see anything in Belgium that you can recommend to be enforced by legislative enactment in England, further than what you have already stated to the Committee?—I think that it should be enacted that ventilation should be produced and conducted by perfectly safe and efficient means, and there are other recommendations which I am prepared to lay before you.

Edward

Edward Cayley, Esq., called in, and Examined.

1521. Mr. *Cayley.*] ARE you practically acquainted with coal mines?—No, I am not.

1522. Have you given scientific attention to the question of ventilation?—To a certain extent.

1523. Have you ever been at any practical experiments in regard to the use of the steam-jet?—Yes; I have seen it applied practically in one case, particularly in putting out a fire.

1524. What was that case?—It was in Scotland.

1525. Upon what occasion?—It was at Alloa, about three years ago.

1526. What was that experiment?—It was the putting out of a fire in a coal-pit in Alloa, about three years ago.

1527. What was the size of the coal-field?—We had to fill about 25 acres with choke-damp.

1528. Was the mine on fire?—The mine was on fire at the time.

1529. How long had it been on fire?—It had been on fire about 30 years.

1530. Had they been able to extinguish the fire by any other means?—They had walled the fiery part of it round, and, in fact, there had been two or three walls made, so that the place was divided into three or four different compartments. They had been beaten over by the fire, but they had got it enclosed within a large mud wall inside. There was about 25 acres.

1531. But practically the fire remained smouldering?—In spite of the wall.

1532. Had the injection of carbonic acid gas the effect of extinguishing the fire?—Yes; it appeared to have extinguished the greater portion of it; but some doubt remains as to whether one portion was not still smouldering. At the east end it had been arched over, in consequence of some of the walls built in the first instance giving way. We could not get in to see.

1533. *Chairman.*] Can you state whether the fire is now out?—There is some doubt as to one corner of the pit. There is no doubt we extinguished the fire in the part we got the gas into; but there was some doubt as to whether some of the residue had been got at. We had no means of ascertaining.

1534. What was the depth of the pit?—I think it was something like 20 yards deep, it was very shallow.

1535. Mr. *Cayley.*] The jet was propelled down the pit and other workings; and did the carbonic acid gas come out at any place?—Yes; it passed down, and we found it coming out. We tested it with lights at a sort of level driven in at the crop. It rolled out there. When we had been blowing the gas in some hours, we found the carbonic acid gas passing out there sufficient to extinguish lights.

1536. The carbonic acid gas was injected by means of a steam-jet?—Yes.

1537. You have heard the evidence of the last witness on the subject of machine ventilation?—Yes.

1538. Do you consider that there is any loss of power in ventilation by a machine?—There is the loss of the friction, of course.

1539. In what respect does that argument not apply to the steam-jet?—I apprehend there is no loss of power on the steam-jet, for this reason; I believe it is the first law of motion, that a body in motion continues to move for ever, unless it is stopped by something to which it communicates its force. Now the steam in passing out at the jet is going with the full force which the steam is capable of exerting, therefore I apprehend that unless it was stopped by some body through which it passed, and against which it impinged, you would have a perpetual motion produced (not in the sense that it is sometimes used), but the thing would continue to move until it was stopped by some other body. Now that body is the atmospheric air, against which it strikes and through which it passes, and therefore it appears to me there is no loss. The steam-jet is not necessarily a steam-jet, but a jet of air answers the purpose exactly in the same way. That air or gaseous substance would continue to move for ever, unless and until it was stopped by some other substance, and whatever other substance stopped it, it must communicate its force to.

1540. Mr. *Locke.*] You are of opinion then, that the application of steam in an ordinary steam-engine, directly puffing against the paddle-wheel, would be more effectual than in its present application by machinery?—No, certainly not; there is no necessary connexion between the two positions. The difference

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is this, you obtain the full power of the steam or of the jet, whatever substance it is, in moving the air; but you cannot obtain the full power of the air in moving the machinery. It would be a misapplication rather than a loss of power. In this case, your object is to move air and not machinery. If your object is to move machinery, you would have a loss in applying it to air, from which it is impossible to obtain its full force.

1541. Do you take any account or attach any importance to the different degrees of density of the two substances used, water and air or steam?—Water you could scarcely use in the same way, although to a certain extent a fall of water does produce the same effect; but the colder the substance, the colder the air, if you are using the jet of air, I believe it has been found by experiments the greater the effect, but it is a very trifling difference. I conceive it to act entirely mechanically, and upon that ground, upon the first law of motion, that it would continue to move for ever unless it was stopped, and to the bodies that stop it it communicates the full energy of its force; that body is the air which you wish to accelerate. I am not practically acquainted with machinery sufficiently to give an opinion, not being a mechanic.

1542. Mr. *Ingham.*] You were present some time during the experiment at the colliery at Alloa?—Yes.

1543. How long?—I was there a fortnight or three weeks.

1544. Mr. *Cayley.*] In what way do you consider the steam-jet is the more powerful agent of ventilation than the furnace?—I consider it to be more powerful, inasmuch as you produce a greater vacuum; you obtain a greater force by it. I consider that it ought to be more economical, because I do not know that it is a necessary part, the burning coal under a boiler, that it is less perfectly burnt than in a furnace; I do not know that that is a necessary part of the arrangement of a boiler. Therefore, I apprehend you must under a boiler get the heat which is applied through the steam, so that you ought to get, if the steam was perfectly applied without loss, the heat of the coal plus the propulsion of the steam, therefore, theoretically I should imagine it ought to be more economical.

1545. Theoretically, do you believe there is a limit to the furnace power of ventilation?—There is a limit, because it is impossible to get beyond a certain heat; if you push your furnace too far, you get a pull of air down one of the sides of the pit, as you do in a smoky chimney occasionally.

1546. *Chairman.*] Would that be so if the air-ways were sufficiently large to bring sufficient air to fill the up-cast shaft?—No; then we should have plenty of ventilation, but if you have a throttle, it of course produces it. With the jet you cannot produce it.

1547. Mr. *Cayley.*] Is it the fact then, that the steam-jet operating not in the way supposed, but in the way you have described, is a much more powerful agent in ventilation than the furnace?—I conceive it more powerful in the way described, but I do not say it is an agent more universally available than the furnace. I think the furnace is a perfectly efficient agent in many cases, but I think the jet, in difficult cases, gives you a command of a much greater power; and, for particular instances, for clearing a mine of choke-damp after an explosion, is perhaps the only means you have.

1548. For these reasons you think the steam-jet, among the mechanical powers, if it may be so called, is a more economical agent than the machines you have heard described to-day?—Yes, I should be inclined to think so; and less liable to danger from explosion.

1549. Have you ever known machinery deranged by explosion?—I saw some at Nit's Hill Colliery; I was there a day or two after the explosion. All the head gear of the pit was blown to pieces. The jet is a very small arrangement of pipes, and if it was blown off it could be put up again in the course of half an hour, and small steam pipes would not be liable to be blown away. At Nit's Hill I saw all the head gearing blown to shivers.

1550. Were you at the Nit's Hill pit shortly after the explosion?—Yes.

1551. Did you hear what means of ventilation they had?—They trusted it to the winds of Heaven; there was no artificial system. They had not had the furnace in for three months; at least, so I was told at the time.

Lunæ, 27° *die Junii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Stephenson.
Mr. Cumming Bruce.	Mr. Fitzroy.
Mr. Baird.	Mr. Locke.
Mr. Ingham.	Mr. Cayley.
Mr. Cobbett.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Herbert Francis Mackworth, Esq., called in; and further Examined.

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1552. *Chairman.*] YOU stated, at the last meeting of the Committee, that you would put in experiments of the different ventilators in Belgium?—Yes; I hand in a description of them (*the Witness delivered in the same*).*

1553. Do you consider that bad ventilation is injurious to the health of the men, as well as uneconomical to the proprietors?—That subject is the most important which affects the workmen in mines and collieries. I believe it produces very great and quite unnecessary injury to the lives and the health of the men; miners are proverbially short-lived; and as they enter the works at an early age, it is at that time it produces the most serious effects, carrying off those of weak constitution, and only leaving the most hardy. In the summer time, as the temperature of the air increases, the ventilation in a mine stagnates; the men are sometimes, for days or weeks, unable to carry on the work, as candles will not burn. The oxygen in the air is quite as essential, or more essential, as support to life, than proper food. The condition of many mines may be easily imagined, by supposing a room containing a number of persons to be hermetically closed until the atmosphere was raised many degrees higher in temperature, and candles would scarcely burn. It is evident that the amount of work to be performed by the men must fall far short of that which would be executed if the supply of air was adequate for their health and vigour. In some mines, where the ventilation has been increased, the men have admitted that they are able to do one-fourth more work in the course of the day. According to an analysis of the air, in some mines in Cornwall, where four men were at work in a dead end, and the candles would hardly burn, the proportions of air were 85 per cent. of nitrogen, 14·7 per cent. of oxygen, and 0·3 per cent. of carbonic acid gas. The average of 18 samples of air gave 17·07 per cent. of oxygen, 82·85 per cent. of nitrogen, and 0·08 per cent. of carbon. When the amount of oxygen is reduced from 21 per cent. to 16 per cent. candles will hardly burn; and when it is reduced to below 14 per cent. it produces suffocation. This deficiency of oxygen, or, which is the same thing, excess of nitrogen, produces a pressure on the chest, a strange fatigue, and feebleness; the breathing becomes quick and heavy; the work is performed with great labour and thirst; and drowsiness, vertigo, and convulsions eventually succeed. The carbonic acid gas, which produces injurious effects on the men, and occasionally death, is an active poison; whereas nitrogen simply acts from the deficiency of the vital oxygen. When the amount of carbonic acid gas is above 10 per cent. it produces death. In consequence of these two deficiencies, in coal and other mines, pulmonary diseases, black phthisis, asthmas of various kinds, and a disease called *anemie*, are more or less prevalent. Dr. Barham, in his Report to Lord Ashley's Committee, states: "Hence it is that almost every miner in the deeper mines is at all times exposed to what he himself designates 'poor air,' by which he means air so impure as to affect him in a noxious way, distinctly perceived by him at the time. Of the less marked degrees of impurity he takes no account. Of the deficiency of oxygen, and the excess of carbonic acid, the presence of a sulphureous acid, or sulphuretted hydrogen, he is not aware; and of smoke, however dense, he seldom takes any notice." By Mr. Lanyon's Table the average age of 2,145 miners was 30 years and four

* *Vide* Appendix.

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months; and of 1,033 labourers above ground the average duration of life was 40 years and four months.

1554. Those are ordinary labourers?—Yes; but from the miners leaving work when they are incapacitated from breathing this noxious atmosphere, and finding employment on the surface, he thinks that the shortening of life amounts to nearer 20 years than 10. In the Report of Lord Ashley's Committee it is stated that the average duration of life of old colliers in Pembrokeshire is 40 years; a surgeon at Narbeth, and another at Coleford, state that they rarely attain the age of 45 years. Mr. Franks says, in the same report, that labour in the collieries of Glamorgan, Pembroke, and Monmouth, is unwholesome, and productive of diseases which have a tendency either to shorten life, or reduce the number of years of successful labour. The diseases in South Wales and Somerset are principally chronic diseases of the respiratory organs, asthma and bronchitis. It would appear that coal in mines is in a state of decomposition; the gases which are found in different mines are an indication of the state of decomposition in which it is; the coal by the absorption of oxygen, forms carbonic acid gas, and this oxygen being taken away from the air, a double deterioration is produced, and a difference in the per centage of oxygen of only one-half the amount I have stated, under those circumstances would produce a similar effect. The fire-damp collieries have usually sufficient air for the health and vigour of the men. I find on a large average that a man does one-fifth more work in the fire-damp than in the choke-damp collieries. Dr. Hanot could distinguish the men working in each by the lividity of complexion arising from the want of oxygen, which acts as the colouring matter of the blood.

1555. Are you the engineer of the Standedge tunnel?—I was; during the time I was the engineer I had an opportunity of seeing the effects of impure air very strongly exemplified.

1556. Where is Standedge?—Between Manchester and Leeds. It is the longest railway tunnel hitherto made. I had occasion to spend nearly a fortnight uninterruptedly under ground, and myself experienced the effects.

1557. Will you state those effects?—Soon after the works were opened, a large proportion of the men, amounting sometimes to one-fourth, were laid up from illness; the average amount of medical and surgical cases were from 200 to 300 per quarter; the average was two-fifths surgical cases, and three-fifths medical cases; the principal ones were diarrhœa, fever of a low type, and inflammatory affections of the chest and windpipe; in some cases complete loss of voice, which remained for some time; the smoke from the boats which passed through the tunnel was productive of very much mischief, the expectoration in many instances being loaded with carbonaceous matter. The cases were more of an asthenic than of a sthenic form; the men who worked inside were pale, and did not possess strong restorative powers; the treatment generally was tonic; there was very little disease when the ventilation became good; the recoveries were tedious; but certainly the pure mountain air did wonders for the men, many cases recovering which, in a less pure temperature, would have died. I feel satisfied that noxious gases, and the want of ventilation, aggravated by the smoke from the boats, increased in a very considerable degree the disease amongst the workmen at the Standedge tunnel. This information is mainly obtained from the medical man, H. H. Broughton, Esq., M.D.

1558. Do you consider that natural ventilation is ever applicable to mines?—Only under extremely favourable circumstances. In the winter months, when there is a difference of temperature of 25 degrees at least, between the down-cast and the up-cast shaft, and the air-ways of the mine are large and laid out in the best manner, under those circumstances alone would the quantity of air be adequate for the men in a colliery where no explosive gases were present.

1559. Does the quantity of air depend on the number of splits and the area of the air-courses?—The division of the air into a number of currents, and the enlargement of the air-courses, is the best method of taking a large quantity of air through a mine; and when an air-course of the same length and area as the first one which there might be in a mine, is added for the purpose of ventilation, the amount of air is nearly doubled. It is called splitting the air, and is the same thing as making two channels for a river instead of one.

1560. Is

1560. Is it the difference of pressure at the bottom of the shaft which causes ventilation, in your opinion?—It is not precisely correct to say that it is the height of the heated column of air which produces ventilation. It depends upon the relative weight of two columns of air, reaching from the highest limits of the atmosphere down to the bottoms of the down-cast and up-cast shafts, and the rise and fall of the air-ways in the mine. That which primarily produces ventilation by rarefaction, is the difference of pressure at the bottom of the up-cast shaft, and a point at the same level in the down-cast shaft. It may be best illustrated by taking a barometer to the top of the down-cast shaft, and then to the bottom of the down-cast shaft; it will be found that the difference of pressure at those two points is less than a calculation taking in the depth of the shaft and the temperature of the air would afford; the difference being very nearly the amount of expansion which the air has undergone in the down-cast shaft, from being dragged through it. As I pass round the mine, following the air current with the barometer, it is constantly falling, until near the bottom of the up-cast shaft, where it stands at the lowest point which it will reach in the mine; the difference between the point at which it stands, and the point at which it should stand by calculation, represents the amount of expansion or resistance which the air has undergone in being drawn through the mine.

1561. You have invented an air-pressure gauge?—Yes. In making the experiments which I have described, I made use of a barometer invented by Descartes, which has a scale six times as open as the ordinary barometer; that was not sufficiently delicate for the purpose, and I contrived an instrument something on the principle of the sympiesometer, but containing a thermometer in the air-vessel, which afforded me a scale fourteen times as open as that of the ordinary barometer. It is only eight inches high, and very portable.

1562. How would you measure the power of ventilation?—By ascertaining the total expansion which the air undergoes in being drawn through the mine, converting that into so many pounds of pressure per square foot, and multiplying it by the velocity at which the air moves.

1563. Is that an accurate mode, in your opinion, of measuring the power of ventilation?—That is the only accurate mode of measuring the effective ventilation in a colliery.

1564. What is the mode which has been hitherto adopted?—In measuring the economy of the ventilation of a colliery, it is generally stated that so many cubic feet of air have been passed through that colliery by the consumption of one pound of coals; whereas, the resistance, in many cases, is double what it is in others.

1565. Mr. *Stephenson.*] Do you consider that, in estimating the efficiency of any system of ventilation, you ought to take into account the amount of drag of the air?—I think it is equally important to take the drag into account with the amount of air which is passed through; otherwise it would be like estimating the economy of a steam-engine without knowing the pressure on the piston, or of a locomotive without the weight or resistance of a train.

1566. In comparing two systems of ventilation, would you not endeavour, in determining upon the best of the two, to make the experiment with the same amount of drag in each case?—Undoubtedly, if it were possible; but in order to compare the ventilation obtained under different circumstances of drag, those drags must be taken into account.

1567. Do you consider that some eminent viewers, who have compared the efficiency of the steam-jet with the furnace, have come to various results, in consequence of having neglected the amount of drag?—I believe this neglect is at the bottom of the serious errors which have been made respecting the steam-jet. In many other cases the drag has been taken into account, to a certain extent, although the economical result has been stated in the way which I have described. This I regret, as it is calculated to mislead the simply practical man, and shuts the door to a strict comparison of the merits of the various ventilating powers.

1568. If you compare two plans of ventilation in the same mine, under similar circumstances, not altering the air-courses at all, nor lengthening them, and consequently not affecting the drag, would the comparative merits, under those circumstances, not be ascertained fairly?—I think it would be a most favourable manner of comparing the two systems of ventilation, to work them

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under the same drag, and up to the same velocity; but fully to understand the merits and applicability of a ventilating power, it is necessary to vary the ventilation with the same drag, and vary the drag with the same ventilation.

1569. Have not many experiments been already made by eminent men in the coal trade, under such circumstances?—The experiments have, in many instances, been satisfactory.

1570. What do you mean by "satisfactory"?—They have afforded the means of comparing the two systems of ventilation correctly, by the great scale and elaborate care with which they were conducted.

1571. Therefore the experiments of that kind which have been made do not tend to any delusion?—No; they have been made, I feel convinced, with the most honourable desire to arrive at truth, and increase the safety of the mines.

1572. They give broad and approximately correct results?—Many of the results are so approximate as adequately, for ordinary purposes, to compare the furnace and steam-jet.

1573. *Chairman.*] Do you agree with the Committee of 1852 as to the existence of a natural brattice?—In consequence of so much stress being laid in that report upon a matter which I had previously thought of no importance, I have directed my attention to discover the existence of a natural brattice; but although I have visited a large number of collieries I have not been able to find one. The ground on which the natural brattice was put forward does not at all exist in mines. The proportion between the diameter and the height of the shaft has not been taken into consideration. When the shaft or the tube become 100 times the height of its diameter, it appears on the face of it to be impossible that the air can descend at the sides when it is ascending at all rapidly in the middle. In point of fact, if the bottom of that column were closed, no fire would be able to burn.

1574. Supposing the air-ways are so large that the amount of air passing them would entirely fill the up-cast shaft, do you think it is possible that a natural brattice could exist?—I think that a natural brattice from such a cause as has been put forward is impossible, except when the velocity of the air is hardly, if at all, perceptible.

1575. Do you agree with the Report of the Committee of 1842, with respect to the existence of a furnace paradox?—I totally disagree with the conclusion which was come to upon that; and I think it is right to point out, that that conclusion was put forward by Mr. Hann and several other witnesses, in total misconception of the evidence which was given by Mr. Woodhouse in 1849. Mr. Woodhouse is made to state, that when the furnace is pushed beyond a certain point, the current of ventilation stops altogether. It is very clear upon a careful reading of Mr. Woodhouse's evidence, that he merely means that the power of increasing the ventilation stops; and the true explanation of that, which has not yet been given, is that the power required to ventilate a colliery increases at least as the cube of the amount of ventilation. It is easy to demonstrate this mathematically, but I have proved it on the furnace and mechanical ventilators by measuring the power and the quantity of coal consumed.

1576. You stated in your evidence, the last time you were examined, that you were inclined to prefer mechanical ventilation to any other system. Do you consider that it would be desirable for the Legislature to enforce any particular system of ventilation?—Under the majority of circumstances, I think the furnace is the most convenient, and possibly the most economical to use; but there are many cases in which mechanical ventilation is preferable and can alone be effectual. I think it must be left to the option of coalowners, with a proviso that there shall be sufficient quantity of air passing through the mine.

1577. Should the power of ventilation always be capable of being increased, to meet such an emergency as an escape of gas from a blower?—I think it is a point of great importance; and it appears to me, that in that point of view, mechanical ventilation offers superior advantages to any other system of ventilation. It has a more expansive action, accompanied by greater uniformity and safety, as I have before shown, and it is capable, in an emergency, of passing a much larger quantity of air than any other means. The speed of machines can be readily increased.

1578. Do you think that accumulations of gas should be removed while the men

men are in the mine?—I think that accumulations of gas should only be removed, and with the greatest care, when the colliers are out of the mine. They ought never to be allowed to occur, and every goaf should be thoroughly ventilated.

1579. Have you any suggestion to make as to the capacity and size of the air-ways, and the best mode of carrying the air through the workings to the up-cast shaft?—I think that the working of a colliery ought to be divided into panels; that the air should enter by an unalterable intake air-course, enter the various panels without doors, and be coursed through the panels by doors and stoppings; that there should be only one inlet and one outlet formed by a regulator, constructed in the most solid manner, at the higher side of the panel, next to the return air-course, and so as to resist any explosion.

1580. In speaking of panels, do you mean the solid pillars of coal which are left to separate one part of the workings from another?—A square room of work, divided from the other rooms or panels by barriers of coal; so that if an explosion occurs, it is confined almost entirely to that panel. If all the doors and stoppings in the panel are blown down, a larger quantity of air passes through that panel than before the explosion, but by a straight course through it, and within a sufficient distance of the working face to allow the men to make their escape without being overcome by the after damp.

1581. Mr. *Fitzroy*.] Has that plan been introduced into any colliery?—Yes; into some collieries in England.

1582. *Chairman*.] Do you agree with the Committee of 1852, as to the utility of refuge stalls?—No; I think they could not be carried out practically. If an explosion occurred and injured them partly, as would probably be the case, they might become filled with suffocating gas.

1583. Where crossings are made, should not great care be taken that they are made of sufficient strength?—Crossings are very weak points in a mine; and in order to build them in the strongest manner, they ought either to be constructed of whole timbers crossed, resting on arching, and supporting an invert above; or they should be constructed of boiler plate, and supported by masonry.

1584. Mr. *Stephenson*.] Are they not usually constructed of strong brick-work now?—Many of them are constructed of brick-work in the manner which I have described.

1585. *Chairman*.] Do not you think that strict attention ought to be paid to the discipline of the mines, in all cases?—I think that is essential to the safety of every fire-damp colliery; and that the only mode to insure it is by the careful superintendence of the viewer, or of the proprietor himself.

1586. Do you think that education of the colliers and overmen would be the means of insuring better discipline?—I think that the education of both is of very great importance. No doubt the education of overmen is of the most importance. In the case of a collier, he becomes more careful and attentive; and by adopting a system of reward or promotion for education and intelligence, I think that the best system of discipline may be introduced into the mines. Of this, some of the best conducted mines in the north of England afford good examples. Education is an instrument of great power for good which position has placed in the hands of the master, if he will use it aright.

1587. Can you suggest to the Committee any means of improving the education of the colliers and the overmen?—In some of the larger collieries in my district the schools are well conducted; they are supported, to a certain extent, by the proprietors; and they reach a perfection which is almost as great as one can expect at first to attain. With regard to the education of the overmen, in some parts of the country they are of a much superior class than in other parts. Many of the Newcastle overmen, who manage collieries in my district, are well skilled and good men, and show how much may be done by introducing a system of education generally amongst that class. I am not prepared to recommend any specific system of education for the overmen. It is a wide field, requiring much consideration.

1588. Is practical mining taught in those schools to which you have alluded?—In the schools for the colliers, they learn usually reading, writing, and arithmetic. Some of the overmen read and educate themselves. There is no school and no book which will give them precisely the information they most want.

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1589. Do you agree with the Report of the Committee of 1852, as to the use of safety-lamps?—I have not met with any well substantiated case of an explosion having occurred from the use of the common Davy lamp; and I think that, with proper usage, it is a safe lamp; still, the glass lamp, by Mueseler (8,000 of which are employed in Belgium, and are much approved of), could be very advantageously introduced into the English collieries.

1590. You would not use the safety-lamp as the means of rendering less attention to ventilation necessary, but rather as an increased security in addition to good ventilation?—Undoubtedly. There is nothing contradictory in the two. The lamps should always be locked.

1591. Are there any circumstances in which you would recommend that the use of the safety-lamp in mines should be rendered compulsory by legislative enactment?—I think it ought to be compulsory in every fire-damp colliery. With the increased light and safety from the Mueseler lamp, no objection can hold its ground. Watson's method of locking is the best I have seen, as the men cannot pick it.

1592. Mr. *Fitzroy.*] Has any improvement lately been made in safety-lamps?—There is one by Dr. Glover, at Newcastle, which is a very safe and very ingenious lamp; but I am afraid that, on account of its weight and price, it is not very likely to be introduced into mines.

1593. Mr. *Ingham.*] What is the price?—Twelve shillings.

1594. *Chairman.*] Do you consider that is the best lamp which has hitherto been invented?—It is one of the most ingenious. I think the Davy is the best lamp for some purposes; and it is the one I always use myself. I have added a second gauze and glass chimney to it, which very much increases the light, prevents the men lighting their pipes, and renders it less affected by currents of air.

1595. Can you suggest to the Committee any precautions which should be enforced by the Legislature as to winding the men up the shafts, so as to prevent a great number of accidents by the breakage of ropes, chains, or any other part of the standing machinery; and also from the falls of coal, or any substance, on the heads of the workmen when they are being wound up the pit?—I think there should be a shaft indicator in every engine-house; that guides ought to be used in shafts; that shafts ought to be walled, and the shaft tops protected; that there should be a cover or bonnet for the men, in ascending and descending; that cages should be employed as far as possible; and that any imperfections in the machinery which might tend to endanger the men should be at once repaired. With regard to precautions against falls of roof, the system which is adopted in the north of England of making the deputies set the props, tends to a considerable saving of life, and is almost universally employed on the Continent.

1596. You mean that if the men are allowed to set their own props they do not pay sufficient attention to putting up a sufficient number of props to ensure their own safety, and consequently lose their lives by their own carelessness?—Yes; and in addition, the props are more regularly supplied into the pit, the deputies are able to watch over the men, and see that they conduct themselves with a proper regard to safety in other respects.

1597. Do you agree with Mr. Dickinson in the evidence which he gave, that the inspectors should, under any circumstances, have the power to stop a mine?—I am not prepared to recommend that they should have that power individually.

1598. Do you agree with him as to the arbitration which he suggested?—I think that some plan of that sort would be very desirable.

1599. Do you agree with him as to the necessity of the Government inspector enforcing a regulation that proper plans of all collieries should be kept?—I think that it is essential. It is provided for in the present Act, but there are no means of carrying it out. A very serious accident occurred in my district a short time ago, in consequence of the inspector's cautions in two instances having been completely neglected. The plans have been subsequently made; and it is now from them perfectly clear, as I stated to the jury at the inquest, that if those plans had been in existence at that time, the accident would not have occurred.

1600. Mr. *Fitzroy.*] When you state that "there are no means of carrying it out," do you mean that there are no means of enforcing it?—Yes; I have taken the opinion of an eminent solicitor on the Act.

1601. *Chairman.*]

1601. *Chairman.*] Was that accident from an inundation?—Yes; I have the plan of the colliery here, if you wish to see it.

1602. Mr. *Stephenson.*] Are the lamps generally, as regards cleaning, under the management of the miner himself, or are they under the management of an inspector to each colliery, whose duty is solely confined to seeing that the lamps are kept in good order?—It is only in the best managed mines that there is a person appointed to that very important post.

1603. Do you think it is important that there should be an inspector in all mines where lamps are used, to look after the lamps solely?—I think there should always be a lampman.

1604. Do not you think that the Davy lamp may occasionally be made insecure by unskilful or rude cleaning?—Yes; I find that where there is not a proper person to look after the lamps, they are often not cleaned more than once a week; and they get into a foul and dangerous state.

1605. May not the miner in brushing his lamp, or in cleaning it, increase the size of some of the meshes?—Yes.

1606. And by increasing the size of the meshes, may he render a lamp which was safe one day unsafe the next?—Yes, it is often done.

1607. Mr. *Locke.*] That objection would apply to any lamp, and it depends on the gauze?—Yes, more or less; most lamps, when they get out of order, become dangerous. The overman should have all suspicious lamps set aside, and shown to him.

1608. Mr. *Fitzroy.*] Have you found great practical inconvenience from the extent of your district?—It is quite impossible to inspect my district satisfactorily without an increased number of inspectors.

1609. You were understood to state that you have not been able to visit all the collieries within your district?—Not half of them.

1610. Do you think it would be possible to lay down any code of regulations which would meet the requirements of all the collieries within your district, or would it not be requisite almost to adopt particular regulations for each particular mine?—I think it could be effected in this way: I would recommend a simple code of regulations, generally applicable, to be carried out for the whole of England; one of those regulations should be, that at each mine there should be printed rules embracing those points of safety which were to be particularly attended to in the mine.

1611. Are not the particular circumstances of each mine so different from others that it is impossible to lay down satisfactorily any code of regulations for the government of the whole, when you have not an opportunity of visiting them and ascertaining their circumstances?—Without having visited them, I am so well aware of the general characteristics of coal mines, that I believe there are a dozen or 15 regulations which would apply to the whole of the collieries in England. I am able to speak, not only from my own information, which I think is quite sufficient for the purpose, but from conversations with the managers of other mines which I have not visited.

1612. Then, when you propose an increase in the number of inspectors, it is not with a view of making particular regulations for each particular mine, but simply for the purpose of enforcing the regulations, or of seeing that the regulations which are already made, are carried out?—Yes; it is with the object of seeing that the regulations are carried out which I propose; and also, even supposing these regulations are not carried out, of becoming acquainted with the general condition, as regards safety, of the whole of the mines in each district.

1613. Then would you propose greater facilities for enforcing the observance of those regulations by penalties?—Yes; I think there should be penalties attached to non-compliance with those regulations.

1614. Do you think it would be possible to obtain such information as to the enforcement of those regulations, as to enable a penalty to be enforced, in the event of an accident arising?—If it were considered that the penalty should be enforced, it would in all cases be necessary to make a visit specially, unless the evidence at the inquest sufficed.

1615. Would you be enabled, after the occurrence of an accident, satisfactorily to ascertain whether it had arisen from an infraction of the regulations, or not?—The coroner's inquest affords me that opportunity, provided I have time to attend the investigation.

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1616. You think that the coroner's jury would be enabled to test the fact, whether the accident had arisen from an infraction of regulations?—I think if I was present at the coroner's inquest, it would afford me the best opportunity I could have of examining into the circumstances of the accident, and of ascertaining whether it occurred from an infraction of the regulations.

1617. What penalty, pecuniary or personal, would you propose to affix for the breach of those regulations?—I think it should include both, at the option of the magistrate, or whoever had to inflict the penalty.

1618. What amount of additional inspection do you imagine would be necessary within your district, in order to guard against any accident from carelessness?—I do not think that any amount of inspection can prevent accidents, it will only prevent a certain proportion of the accidents. The comparison which I have given between the number of accidents in England and in other countries, affords an opportunity of judging of the extent; but I think if the average amount of inspection was such as to enable an inspector to visit a mine once a year, there would be a great diminution in the number of accidents.

1619. How many mines are you enabled to visit within your district every week?—Three or four.

1620. Do you think that the presence of an inspector once a year in a mine would be sufficient?—Yes, on the average; some mines he would not visit more than once in two years, others he would visit every six months, or more frequently if it were necessary.

1621. Would it not be necessary to have sub-inspectors, who were practically conversant with mines of all descriptions?—I think that an arrangement might be made to have persons of superior acquirements, who would very soon become sufficiently acquainted with the dangers of coal mines to be able to point out when a mine was safe, and when it was dangerous. I think that young men of the highest scientific education, such as the first pupil each year at the Museum of Economic Geology, should be gradually introduced into the corps.

1622. Do you think that a large proportion of the accidents which now occur in mines arise from recklessness, or from ignorance on the part of the proprietors?—There are but few accidents which arise directly from neglect or ignorance on the part of the proprietors; the manager of the mine is, I believe, in the majority of instances, more or less in fault when an accident occurs.

1633. Do you think that an improved system of education for the miners, or any means by which they might become acquainted with the result of carelessness on their part, would tend more to the security of the mine than an increased number of Government inspectors?—If the mines could be as well managed, and have as good managers as some of the best mines in the north of England, such a result might be arrived at; but I think it is impossible to have the managers so well educated. It would be at least 10 years before any perceptible effect would be produced in the safety of mines by the education of the managers. It would be uncertain whether men so educated would become managers of coal mines, and I believe that the most direct effect is produced by inspection, and that in the long run it is most effectual. By communicating information to the managers, visiting mines, and pointing out sources of additional information, I believe that a good deal of information of a most useful kind is given, accompanied with a certain pressure of responsibility, that they shall carry out the recommendations which are put before them. I do not, however, the less advocate such education.

1624. You were understood to state that a great proportion of the accidents arise from carelessness on the part of the managers. Supposing a heavy penalty were imposed upon the proprietor of a mine in cases of proved carelessness on the part of the managers, do not you believe that the enforcement of such a system would tend better to the security of life and the prevention of accidents than even an increased number of Government inspectors?—That is not the way in which I think it should be remedied; I believe it would not have great effect.

1625. You have not answered the question with respect to the number of inspectors who would be requisite in your district to put the whole system of mines upon a satisfactory footing?—I think that in my district there ought to be about five inspectors.

1626. Five in addition to yourself?—Yes.

1627. And

1627. And it is your opinion that the presence of the inspectors, on an average, once a year in a mine, would be as beneficial as the enforcement of greater precautions, by visiting the proprietor with a penalty, and consequently making it imperative on him to enforce greater regularity and care on the part of his manager?—I think that the adoption of such a system as you propose would induce the proprietor to look on that penalty as simply something to be added to the capital of the mine; and I think that the most effective system of diminishing the number of accidents, is to associate an increased inspection with the adoption of a code of regulations such as I have described.

1628. Enforced by a penalty?—Yes; to enforce a penalty for an infraction of the rules, and not for the inefficiency of the manager, because an owner is not always able to judge of the competency of the manager whom he appoints to a mine.

1629. Mr. *Cayley.*] Do you see any objection to combining the two systems which have been suggested; that is to say, increasing the number of inspectors, and attaching penalties where great carlessness is proved?—In the regulations which I have thrown out, a portion of Mr. Fitzroy's proposal is embraced. I think there should be some kind of regulation that the manager should be a competent person to discharge his duties; and in case an accident occurred, the owner should show how far he had endeavoured to procure a suitable and efficient manager; but to say that the owner should be fined whenever an accident occurred from the carelessness of his manager, would not, I think, work practically, as the most difficult point after a colliery accident is to fix the responsibility.

1630. Mr. *C. Bruce.*] You would throw the responsibility very much on the manager?—Yes; it is to them almost alone that the dangerous condition of many collieries is attributable.

1631. Would you exempt the workmen?—By no means; the penalties to which I have referred should be levied upon workmen in cases where they had broken through the rules. The miners' regulations in each colliery which I have alluded to, would apply more particularly to them, and by being specially mentioned in such a code as I have alluded to, they would, to a certain extent, take the force of law and become, as it were, bye-laws in the mine.

1632. Mr. *Fitzroy.*] Do you think it would be desirable to make it imperative upon mine owners, to employ as managers only men who could undergo some examination as to their practical knowledge in the working of mines?—There is no doubt that course would be desirable; but I am not able to see how that could be carried out in this country at the present time; it is a point at which we may gradually arrive.

1633. *Chairman.*] How would you propose to arrive at that point?—There must, first of all, be the means of education before you can expect the men to be educated; there must be a certain time allowed for men to qualify themselves, and there should be persons appointed to examine them.

1634. Can you suggest any means for educating men in the manner you propose?—I am not prepared to suggest any means.

1635. Mr. *Fitzroy.*] What salary do the overmen receive?—A good overman gets 100*l.* a year.

1636. Mr. *Locke.*] In your judgment, is it possible, for that amount of salary, to obtain a good practical man for the management of a colliery?—You may obtain a good overman for a colliery, but I think that all collieries ought to be superintended by viewers, according to the system which has been found so effectual in the north of England.

1637. Whom would you appoint to examine a new candidate as a manager of a colliery?—I am not prepared to answer the question, not having considered sufficiently minutely the best mode of educating the overmen.

1638. Whom would you appoint to examine whether a man was or not fit to be a viewer in your district, or in any other district in the kingdom?—I am not prepared to suggest any board of examination.

1639. Do you think that a Committee of Parliament would be fit to do it?—I think they should be well acquainted, scientifically and practically, with the working of coal mines. The best persons to make the test would be the persons who had to teach.

1640. Mr. *Ingham.*] Would the general body of inspectors form a good body

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for the purpose?—Yes; if there was a sufficient number qualified by the highly scientific education I have mentioned, and long practical study.

1641. You have spoken of having the number of inspectors increased in the proportion of five to one; do you think that the united body of inspectors would form a good Board for the purpose of examining candidates for the situations of managers?—I think they would be quite competent eventually to do it, but I never contemplated submitting the viewers to an examination.

1642. Mr. *C. Bruce.*] Do you think that if certain qualifications were necessary for an overman, such an appointment might be left to competition?—I think that a great deal might be done in that way; I am not prepared to say that would be sufficient.

1643. You have stated that you could not suggest any machinery for the education of overmen which you would think it desirable to give, and therefore I asked whether you thought that by laying down a certain amount of qualification as requisite for employment in this situation, the natural competition for such employment would not induce a sufficient number of persons to qualify themselves for such situations?—I think that would be the best course to adopt at the present time, until more complete machinery could be carried out.

1644. Mr. *Cayley.*] The questions refer, not so much to the mode in which the education is obtained, as the test of the qualification; what body would you recommend for that purpose?—The body of inspectors seems to be the first that presents itself.

1645. Supposing it were necessary to bring the body of inspectors themselves under some central body, do you conceive that a Board of three gentlemen might be instituted, with the power of testing the qualifications of a candidate?—They are persons who would be able to test the scientific qualifications of an inspector; but I am not aware of any Board that would be able to test their practical qualifications.

1646. Supposing there is no such Board already existing, do you think it is impossible to institute such a Board?—Such a thing is possible; but I do not see how it can be carried out.

1647. Can you imagine no Board or Commission which could by possibility be instituted, which should have the capacity of judging whether an inspector was a proper appointment, or a viewer was a proper appointment, or an overman was a proper appointment?—I think there is a Board now which might be made use of for that purpose; that is the Board of Inspectors; they would be qualified to judge on any future appointments of inspectors, whether they were sufficiently well informed, or they would be able to judge of the qualifications of overmen and managers, if there were no other means of providing for it.

1648. Who should judge of the appointment of inspectors themselves?—The inspectors themselves.

1649. Then you would have them a self-elected body?—No; those who had already the acquirements, and who were well qualified for their office, would be the most competent persons to judge of the qualifications of any persons who were to be taken into that body. This is approving, not appointing.

1650. Have not the last inspectors been subject to some kind of examination?—I am not aware that they have.

1651. Has there not been a different mode of selecting the last one or two inspectors, as distinguished from the mode in which the others were appointed?—No; but I think a strict examination highly desirable.

1652. Mr. *Fitzroy.*] You would propose that competent parties should test the qualifications of the sub-inspectors whom you propose to appoint?—Yes, I think it is desirable; without the highest qualifications they will do more harm than good.

1653. Whatever body would have been competent to test the qualifications of the sub-inspectors, would be equally competent to test the qualifications of overmen, whose examination it was wished should be taken?—Undoubtedly.

1654. You have stated that you think all collieries should be inspected by viewers; do you propose that there should be viewers for so many collieries, or do you contemplate one viewer for each colliery?—The plan that I proposed is the one which has been found to work best, after very long experience in the north of England, both in economical and other points of view; that is, for one viewer

viewer to look after a number of collieries, according as his time allowed him to do it.

1655. Then that viewer would exercise the same powers as the sub-inspectors whom you propose to appoint?—No; the viewer has a power to control everything in the colliery; he is employed by the proprietor. The sub-inspector would have no other power than to point out the regulations had not been carried out, or that other regulations for safety were desirable in a particular colliery. He would come but once a year; the viewer every week.

1656. Would he be appointed by the coalowners themselves?—The viewers are appointed by the coalowners. I find great improvements in collieries when viewers are appointed; it is the wisest course a proprietor can take, and I am only surprised it is not more generally done.

1657. Mr. *Cayley*.] Would not a viewer stand in the capacity of the steward of an estate, and a sub-inspector in the position of an auditor of an estate?—No; the sub-inspector would have no right to interfere in the works. I do not propose that the sub-inspectors should have more virtual power than the present inspectors possess.

1658. *Chairman*.] You do not propose to make it incumbent upon a coalowner to adopt any particular plan for managing his own coal mines, but you would leave him to conduct them in the way he thought proper?—No; I would only recommend that course which I have suggested to many coalowners, as being the most economical means for themselves of managing a colliery; and it is being every day more and more adopted.

1659. Mr. *Fitzroy*.] Would you propose to give to anyone the power to stop a mine, under any circumstances?—After it had been decided, upon an arbitration, that a mine was unsafe, I think that a magistrate should have the power to stop the mine.

1660. *Chairman*.] Supposing that a mine were in a highly dangerous state, and you were to proceed to an arbitration, would it not be possible that an explosion might take place, and a great many lives be sacrificed during the progress of the arbitration?—I think that practically it would amount to the inspector stopping the mine; the first caution would be one of the strongest kind.

1661. Mr. *Cayley*.] Do you see any objection to that?—No other objection than that I am reluctant to take the responsibility out of the coalowners' hands.

1662. If a mine is extremely dangerous, according to your opinion, would not the responsibility be quite as heavy in allowing a number of men to be hurried into eternity?—I should try all that persuasion could do. My difficulty is, that it is possible for an inspector to go through a mine, and for circumstances to arise immediately after his inspection, such as leaving open a door, or the giving off or a blower of gas, which may cause an explosion; and then the question immediately would be, why did not the inspector stop the mine. I believe it is taking the responsibility out of the hands of the coalowner or manager, and putting it on the inspector, when the inspector has not the means of judging whether he is performing his duty with a full knowledge of all the facts.

1663. Mr. *Stephenson*.] Does not that imply, that inspection really will not tend to prevent accidents?—Quite the contrary. It will prevent a great many accidents, but I do not recommend it as preventing all, or nearly all; and I must point out once for all, that it is impossible for an inspector to ascertain every liability to accident in any mine which he visits, the manager himself cannot always do it; and no reasonable man would suppose that because an inspector had visited his mine, and found no fault, that his mine was perfectly safe.

1664. Mr. *C. Bruce*.] You stated that you would look principally to the managers for preventing accidents in mines; would you give to the inspectors any power of objecting to a particular manager continuing to hold a mine, from a want of fitness for his duties?—I do not think that an inspector should have the power of dismissing a manager.

1665. What power would you give the inspectors with regard to that?—The coalowners should employ competent managers; and the inspector would then point it out, if in his opinion that regulation was very glaringly not complied with.

1666. *Chairman*.] Who would be the judge of whether a manager was competent

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petent or not?—The matter would be decided by some accident occurring, or by some act which proved it.

1667. Would not that be locking the stable after the horse was stolen, if you are only to decide upon the competency of a manager, after some serious accident has occurred?—It is a similar case to the other. I think the responsibility should rest on the coalowner. The manager would be responsible for the safety of the mine, and the coalowner would be responsible for the manager.

1668. Mr. *C. Bruce.*] In case of his failing to act under that responsibility, would you give any power to the inspector to enforce his so acting, by the discharge of a person who was considered by the inspector to be incompetent for his duties?—No.

1669. *Chairman.*] Do you think it would be better, in all cases, to leave it to the discretion of the coalowner, to employ men whom he thought were most competent, and would carry on the workings in the most satisfactory manner, leaving only to the inspectors the power of enforcing fines in particular cases, such as you have stated?—Yes, I think it is necessary to be very careful indeed, in not shifting the responsibility from the manager to the inspector, because the inspector is not in a position to judge fully.

1670. Mr. *Cobbett.*] You were understood to state, that you could frame 14 or 15 regulations which would be applicable to all the collieries in your district?—Yes.

1671. Did you not also say that you had prepared them?—Yes; I will read the more important of them. "1st. An artificial means of ventilation shall be employed at every coal mine, so as to produce a constant and active current of pure air throughout the working parts of the mine, as well as to dilute and render imperceptible all noxious gases. 2d. The ventilation shall be produced and conducted by perfectly safe and efficient means. 3rd. The descent of air, supposed to be more or less impregnated with fire-damp in a mine, being attended with great danger, it shall, as far as possible, be avoided, and can only be permitted by the express authority of the manager or proprietor; and when accompanied by constant vigilance and precautions against the dangerous accumulation of fire-damp. 4th. All dangerous or defective places shall be fenced off, or clearly indicated. 5th. Every accessible part of a coal mine shall be carefully examined, and its safety assured by a deputy or fireman, before the workmen are allowed to enter. 6th. Locked safety-lamps shall be exclusively employed in every coal mine, or part of a coal mine, where the presence of fire-damp or other explosive gases has been ascertained; they shall be opened only at such stations as may be determined on by the manager, and by men selected for that purpose. 7th. No blasting with gunpowder shall occur where safety-lamps are exclusively used, until the vicinity of the place has been ascertained to be free from fire-damp by deputies specially selected. No substance capable of emitting flame shall be employed to ignite the gunpowder. 8th. The safety of all and every part of a colliery, its works, ropes, machinery, shafts, &c., shall be entrusted to competent and specified persons, who shall exercise a vigilant supervision. 9th. The tops of and openings into all shafts, whether in work or abandoned, shall be made safe. 10th. When men descend any shaft by a tub, skip, or cage, they shall be protected by a bonnet or cover. 11th. Whenever an engine is employed to raise or lower men into a coal mine, an indicator, showing the position of the load, shall be placed conveniently in front of the engine-man. 12th. Two safety-valves of adequate area, with weights and levers marked to indicate the pressure of the steam, or an open feed-pipe shall be used for every boiler. 13th. A sufficiency of props shall be supplied wherever required in a coal mine, and the deputies shall satisfy themselves of the efficient setting, and of the safety of the roof. 14th. Printed rules, setting forth in detail the special precautions to be adopted in all respects of discipline and safety, whether herein generally described or not, shall be affixed and made known at each colliery. 15th. Fines, with or without imprisonment, should be inflicted by a magistrate for non-compliance with these rules; which should be doubled after the neglect had been pointed out by an inspector. 16th. Power should be given to carry out the 3d Clause of the Inspection Act, Vict. 13 and 14, chap. 100, respecting the making of plans, by a fine, increasing for every day which may be allowed to elapse after a reasonable period for their completion. 17th. Facility should be given to the families of those who are killed, to recover damages at the County Courts, under

under the Act 9 and 10 Vict., chap. 93, commonly called 'Lord Campbell's Act.' 18th. All pits should be walled, and guides, as far as possible, be adopted. 19th. All important defects in the ropes or machinery, which may increase the danger to the men using the pit, shall be immediately remedied. 20th. No persons shall be allowed to use the shaft or incline whilst a full tub or tram is ascending or descending; and the number of men, or boys, ascending or descending at one time, shall not exceed one-half the usual load of coals. 21st. Iron mines should be included in the Inspection Act, and the same regulations should be adopted as in coal mines, as far as they are applicable."

1672. Mr. *Cayley.*] When you state that you would not interfere at all with the practical management of a mine, what would you have an inspector do, in case your suggestions were carried out by legislation, if one of the vigilant supervisors, whom you have recommended, were not appointed by a coal proprietor?—In case it was an urgent matter which came before the attention of an inspector, it might be competent to him to take the case before a magistrate, and have it argued, and the penalty inflicted.

1673. Supposing your suggestions were carried out by legislation, would you not make them imperative?—Yes.

1674. Then the magistrate would merely have to decide whether the fine was leviable?—It would be necessary to decide whether there was a sufficient person in that position or not.

1675. *Chairman.*] Would you not think it necessary to add to those rules, that in every case where safety-lamps are used they should be cleaned and examined daily by one single man, and if necessary, repaired by him?—Yes; I think it would be desirable.

1676. Mr. *Cayley.*] Would you add to that list of rules, supposing the mine was, in your opinion, in an extremely dangerous state, and such as to endanger human life, and the manager refused to adopt your suggestion as to improving the ventilation, that the inspector should have the power of stopping the working of the mine?—Not until after an arbitration. I should be able to enforce locked safety-lamps at once, and the remedy of most of the serious defects.

1677. Mr. *Ingham.*] You have mentioned that in the north of England, in some of the better managed mines which are under your inspection, the rule is to have a viewer of superior attainments, who has charge of several collieries?—Yes.

1678. Who is the officer next in authority to him; is it the overman, whom you have mentioned at a salary of 100 *l.* a year, or is there an intermediate officer between the overman and the chief viewer?—At the large collieries in the north of England, there is frequently an under-viewer.

1679. A local viewer?—A local viewer.

1680. Are you aware of any case of a colliery in the north of England being left in the charge of an overman, and with no person above him except the principal viewer, who has several other collieries under his superintendence?—Yes; there are many in that position; and some of the collieries in the north of England are without a viewer at all.

1681. And in the charge of an overman only?—Yes.

1682. Mr. *Cobbett.*] Is it not practicable to lock up the lamps, when the men take them down into the pits?—It is the common practice in some mines. It is practicable.

1683. And it is the practice abroad?—Yes; it is the law in Belgium.

1684. Is that one of your regulations?—Yes.

1685. *Chairman.*] And that the key should be kept by the man who has to clean the lamps every day?—Yes; that they should be locked and unlocked in special places appointed at the bottom. There must be two or three men who have keys.

1686. But no man, except those who were specially appointed, should have keys which would open the lamps?—No.

Martin Jude, called in; and Examined.

Martin Jude.

1687. *Chairman.*] YOU were examined before the Committee of the House of Lords in 1849?—Yes.

1688. You then stated that you had been 34 years engaged in working in collieries?—Yes.

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1689. Have you been working in collieries since your examination in 1849?—No; I have not.

1690. What is your present occupation?—I am keeping an inn at Newcastle.

1691. You are the secretary of the Miners' Association?—Yes.

1692. Did you receive a circular which was sent down?—I did.

1693. In your opinion, from what you have heard from workmen, are the mines in a better condition in the Northumberland and Durham districts, as to ventilation, than they were in 1849?—I think they are not improved at all.

1694. Do you think there is no improvement in splitting the air?—The air-splitting was in operation at that time.

1695. Is it not carried out more extensively and with greater success now than it was in 1849?—Not that I am aware of.

1696. Have the sizes of air-ways been improved since 1849?—There has not been any increase in the area of the air-ways, as far as I know.

1697. Are the workmen anxious to recommend any particular mode of ventilation?—No; we wish to confine ourselves to this, that there shall be a sufficient quantity of air, the owners being responsible for that sufficient quantity.

1698. You are in constant communication with the working people of that district?—Yes.

1699. What are the particular grievances that the working people complain of?—They complain very much of the five-quarter seam in the county of Durham, that the heavy gas is so much, that sometimes they are obliged to work where their candles will not burn, within several feet of the face.

1700. The heavy gas that you allude to being the choke-damp?—Yes.

1701. The reason of that is, that there is not sufficient ventilation in the mines?—There is in many cases a sufficient amount of air, if it were properly conducted, but there is a want of brattice to convey it to the working face; there is a want of doors and proper stoppings.

1702. How would you enforce the conveyance of air, in an efficient manner, up to the face of the workings?—Simply by inspection, I think.

1703. Do you think that an inspector should be empowered to order brattices to be carried up properly to the face, and that a sufficient quantity of air should be carried round the brattice, so that a man might breathe a sufficient quantity of pure air?—Yes.

1704. Can you state what quantity of air should be allotted to each man?—I cannot say.

1705. Have you ever seen the steam-jet in operation?—I have been down the Seaton Delaval pit lately, and have seen it in operation there.

1706. Did you find the ventilation in the Seaton Delaval pit better than in any other pits?—It is much superior to any pit I ever was in before.

1707. Have you ever been down the principal pits which are under the superintendence of Mr. Wood?—No; I never worked for Mr. Wood, except at Tyne Main Colliery, several years ago.

1708. Is Seaton Delaval Colliery under the superintendence of Mr. Forster?—It is.

1709. Do you attribute the better state of ventilation entirely to the steam-jet?—There was a larger amount of air, generally speaking, than ever I felt in a pit; and when I went through the workings I went into most parts of the workings where the return air came from; I found an entire absence of all gas, and the workmen working in a cool atmosphere.

1710. Is Seaton Delaval a very fiery pit?—The overman informed me that there were some places where gas was given off much more than in the part I was in, but additional means are employed to carry it off.

1711. In any part of Seaton Delaval pit, were the men working with safety-lamps?—They were working with safety-lamps in the broken or pillar working which I visited.

1712. Are the air-ways in Seaton Delaval pit larger than the air-ways in any other pits that you have been in?—A great deal larger.

1713. Do not you think that the size of the air-ways has something to do with the increase of the quantity of air passing through the workings?—I should think it would be so.

1714. Mr. *Cayley.*] You do not know what the state of the Seaton Delaval pit was before they commenced working with the steam-jet?—I have heard the

the workmen state that previously to the steam-jet being put in operation, there was always the presence of gas at the edge of the goaves.

1715. Mr. *Ingham.*] You say that you have not worked under Mr. Wood in any colliery: what are the principal collieries you have visited where furnace ventilation was not carried on?—I worked in Walker Colliery a long time; but furnace ventilation was the only mode then employed.

1716. Have you visited any other collieries since you ceased to be a workman?—Not the interior.

1717. Have you seen the South Hetton Colliery?—No; not the workings.

1718. Have you not been recently at Seaham, and seen some collieries there?—I was at the colliery, but not down the pit.

1719. Supposing that some regulations were issued, to be observed in the mines, do you think that if the pitmen in the colliery saw that they had been broken, they would take the trouble of giving information, or that they would be indifferent to it?—If they knew it, they would take the trouble to give information.

1720. It has been stated, as a matter of opinion, that they are so careless about those things, that if there were regulations they would allow them to be broken without taking any notice?—It would not be carelessness on their part. It would be intimidation or fear that would produce that effect.

1721. If they knew there was a Government inspector coming round, whose duty it was to give encouragement to the making of honest complaints, do you think there would be backwardness on the part of the men in giving him materials to act upon?—I do not think there would.

1722. *Chairman.*] Do you think that on the size of the air-ways for the in-take and the return air depends the safety of the pit, more than anything? I think that is the principal thing.

1723. Do you think it is the opinion of persons in the neighbourhood of Northumberland, that the air-ways are sufficient to prevent explosions?—Not generally; they are very deficient.

1724. Do you think there should be distinct air-ways to convey leading currents of air, through which there should be no passing?—I think it should be essential not to have any air-way obstructed by the passage of corves and tubs.

1725. Do you think the goaves should be ventilated—As far as it is possible. I perceived that at Seaton Delaval it is so to a great extent.

1726. At Seaton Delaval is all the gas taken out of the goaves?—I cannot say that; but for the great distance I travelled I found none.

1727. You went into the goaves yourself?—Yes.

1728. You found the goaves free from gas?—Yes.

1729. And air circulating through the goaves?—Yes.

1730. Mr. *Fitzroy.*] Have you known any accident occur from carelessness in the use of the safety-lamp?—No.

1731. You have never known miners open their lamps in a fire-damp mine?—Not one.

1732. Mr. *Cayley.*] Do you remember an explosion taking place at Killingworth Colliery?—Yes.

1733. Do you know what was the cause of that explosion?—I cannot exactly say: but the general opinion of the workmen was that it was at the Davy lamp.

1734. Have the men worked with the Davy lamp since that explosion?—No; they refused, at that explosion, to work any longer with it, and Mr. Wood conceded their request to work with the Stephenson lamp.

1735. *Chairman.*] They do not work with naked lamps?—Not much; there are some naked lights worked with.

1736. Do the men generally prefer the Stephenson lamp to the Davy lamp?—At that colliery they generally do.

1737. Mr. *Cayley.*] You wrote to me for some copies of the Report of last Session?—Yes.

1738. What was the opinion of the colliers, generally speaking, upon that Report?—They highly approved of the recommendations in it, and were satisfied that if legislation commenced on that Report, it was all that they wanted.

1739. Has there been any excitement in the colliery districts, with regard to

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the furnaces, since that Report came out?—I think there has not been any great excitement.

1740. Do the furnaces burn any brighter, or produce any more ventilation, than they did before that Report?—There have been some attempts to improve them and to increase their power.

1741. Mr. *Fitzroy.*] Have those attempts failed?—Not all.

1742. Then the ventilation in the mines has been improved since last year?—In some particular collieries, but not generally.

1743. You were understood to state, that in your opinion there had been no improvement since you gave evidence before the Committee of the House of Lords in 1849?—No improvement in the principles of ventilation.

1744. Mr. *Stephenson.*] You have stated that generally the system of ventilation, in the north country mines, has not been improved since you gave evidence in 1849?—No.

1745. In some few cases you think there has been improvement?—Yes; I have learned that there have been great improvements at Great Hetton Colliery, by additional power being added.

1746. When you speak of additional power, do you mean by an enlarged furnace, or by the application of the steam-jet to aid the furnace?—By an enlarged furnace, an increased size of air-ways, and other necessary appendages.

1747. *Chairman.*] Are there more shafts?—No.

1748. Mr. *Cayley.*] Are there more furnaces?—There is more furnace-power.

1749. Does not Mr. Wood burn three furnaces?—So I understand.

1750. *Chairman.*] All the heat from those furnaces goes up the same shaft?—Yes.

1751. Is it your opinion that the present mode of sinking two shafts alongside each other is defective?—I think it is very defective.

1752. How would you propose to remedy it?—I should, at least, have two shafts sunk at the dip of the colliery, and one or two of equal area at the rise of the colliery.

1753. Would it not be sufficient to have one shaft, provided the one shaft had as great an area as the two?—There is always great danger in having a brattice in a shaft, and they would always require a brattice-shaft, if there was only one, until they got the whole pits sunk and ventilated.

1754. Would you propose that the shaft to the rise should be made useful for conveying coals up the pit?—No, simply as an air-shaft.

1755. If it be an up-cast shaft, why need it be bratticed?—The down-cast shaft is alluded to, at the dip.

1756. I was speaking of the up-cast?—One large shaft will do there.

1757. Provided the area of that shaft was as large as the two?—Yes.

1758. Therefore you would have one large shaft at the rise of the colliery, and you would have two shafts to wind the coals up and down the pit, which would serve as down cast shafts?—Yes.

1759. To what depths have the proprietors to sink in order to reach the coal, as an average, through the district to which you belong?—I think about 120 or 140 fathoms.

1760. Can you state the expense of sinking a shaft?—The physical labour of sinking a shaft is from 6 *l.* to 8 *l.* per fathom; or about 1 *l.* per fathom per foot diameter of shaft.

1761. In some districts do you not suffer from a great in-rush of water?—Yes; that is an additional expense.

1762. Does not that make the sinking of a shaft very expensive?—Yes.

1763. Do you know Monkwearmouth Colliery, at Sunderland?—Yes.

1764. In such a colliery would it be possible to sink as many shafts as you allude to?—I may state, that at Seaton Delaval Colliery there are six shafts already sunk, so that there would be less expense in sinking three than in sinking six; in almost all the collieries there are three or four shafts sunk, but they are sunk at a certain place in the colliery, and the air has to travel all the distance round the colliery to return to the up-cast shaft.

1765. Can you give any idea of what number of acres should be worked by one shaft?—I could not say particularly; it might be 50 acres for one shaft.

1766. Do you think, taking the district to which you belong, that there are not enough shafts sunk in reference to the number of acres which are worked by

by each shaft?—I believe there are not so many shafts as there should be to ensure safe ventilation.

1767. Mr. *Ingham.*] You do not express a very decided opinion as to the area of acres which may be worked by one shaft?—No.

1768. Mr. *Stephenson.*] Why do you prefer two shafts being sunk, one at the dip and the other at the extreme rise of the royalty?—My chief reason is, that if an explosion takes place, instead of the air-stoppings being all blown out, and rendering the passages all blank, there will be a continuous stream of air going over the pit, not subject to any stoppings.

1769. But it would be only going from the lower shaft to the upper shaft?—It can be conducted through the whole of the workings, and then made to ascend the up-cast shaft.

1770. The parts of the mine which have to be ventilated by the air being split, if an explosion takes place, would equally be left in a stagnant state, whether you had the air going direct from the lower shaft to the upper shaft, or whether you had to bring it back to the lower shaft again?—There would be a certain portion of excavation liable to that.

1771. Supposing you have a drift direct from the lower shaft to the upper shaft, and the bords are worked away from each side of that drift, when an explosion takes place, will not the air ventilating through the mine be entirely confined to that single drift between the one shaft and the other?—No; it could be conveyed out of the drift to all the workings, in the same manner as it is now.

1772. I am supposing an explosion to take place, and blow down the stoppings, which is an assumption you made yourself; suppose the air is divided, in ventilating three or four sheths or bords, when the stopping is knocked down of course the air will go from the down-cast shaft to the up-cast shaft in the shortest possible way?—Yes.

1773. If it does go between the one shaft and the other in the shortest direction, will not the sheths of bords on each side of that air course be left in a perfectly stagnant condition?—Yes.

1774. Therefore there is no advantage derived from having the one shaft at a lower level, and the other shaft at a higher level, as regards the position of the works after an explosion has taken place?—There is no difference; but there is this advantage, that the workmen, if they are able to get out at all, having a continuous stream of air passing between the shafts, can reach that sooner than they can the bottom of the up-cast shaft, or the down-cast shaft.

1775. In a large royalty, extending perhaps over an area of two miles, have you ever known an instance, where you would recommend, as the manager of a colliery, the sinking of two shafts, and the working of a mine in that way?—I would recommend it, in the largest royalty.

1776. Take a large royalty with two shafts sunk down, and that they are a mile apart; how long would it take you to drive a double headway between these two shafts?—That would depend on the height of the seam and other contingencies. I should say six or 12 months.

1777. That is, half a mile each way?—Yes.

1778. Did you ever know a drift of that kind driven at that rate?—I have not known it, because it has never been put in practice.

1779. What do you think a good hewer ought to drive in a double headway per day?—Six feet for two men in one day.

1780. Half a mile at two yards a day, will be upwards of 12 months?—Several men can be employed in one day.

1781. *Chairman.*] Do you mean two yards in 24 hours?—One man six hours, and another man succeeding him for six hours again.

1782. How many yards could be driven in the 24 hours?—Seven or eight yards. All depends upon the nature of the seam of coal and the number of men employed. I wish also to state that I think that plan would be advantageous when they came to work the pillars, and more so than in the previous excavation of the workings, because in working the pillars back from the shaft they drive the air necessarily through the goaf.

1783. Mr. *Stephenson.*] You have stated that you walked through a goaf some time ago?—Yes.

1784. What colliery was that?—Seaton Delaval.

Martin Jude.

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1785. What was the extent of the goaf when you walked through it?—The goaf was several acres in extent, but I went in but a few yards.

1786. The seven or eight yards of goaf in which you walked might be affected by the air-courses adjoining it?—Just so.

1787. Would any air-course which you ever saw affect a goaf extending over eight or ten acres?—I think not under the present system.

1788. The goaf through which you walked through must have had a good roof?—A part of the roof had fallen.

1789. And the other admitted of your walking through it?—We climbed over the falls, and on to the top thereof.

1790. What were the means of guiding the air through that goaf?—They fetched it from the whole workings, right down to the up-cast shaft, through that edge of the goaf.

1791. Would not the ventilation of the goaf rather be accidental than scientific or practical?—I think there is a great deal of accident about it; but they bring the air down that way purposely, and carry off the gas as made.

1792. With a large goaf, do you think that anything like certainty can be obtained in ventilation?—Not a moral certainty.

1793. *Chairman.*] You have stated that when you went down Seaton Delaval mine, you did not go into the worst part of the workings, and that you were told there were worse parts than those parts which you visited; why did you not go into the other parts?—From the distance I had travelled, I felt so fatigued that I could not go further; I went several miles.

1794. Do you think you could form an accurate judgment of the ventilation of that pit unless you visited the parts which were said to be the worst ventilated?—Those other parts were better ventilated; but there was more danger in that part, and of course they put more brattices in, and paid more attention to it, than they did to the part which I visited.

1795. Mr. *Stephenson.*] You have stated that you thought that by a vigilant system of inspection you would get better air up to the face where the workmen were employed?—Yes.

1796. What kind of inspection would you propose to secure that?—A system of Government inspection, as at present laid down.

1797. How often would you have the Government inspector go down for the purpose of examining each bord and ascertaining whether the brattices are sufficiently extended towards the face?—I think that he should not be absent more than a month.

1798. Supposing that he was absent for a month, might not the men be suffering three weeks of that month from want of bratticing?—I should hope that monthly inspection would ensure safety.

1799. As the bords advance every day they require fresh bratticing to be put up, and the ventilation of any one bord depends to-day on the amount of bratticing put up this very morning?—Yes.

1800. Therefore what security would you have for having the brattice carried up within a certain distance on the face of the work, by a person coming there once a month?—In my opinion there would be a sufficient stock of brattices in every colliery in that way, whereas the reason they are not put up now is, that they have not a stock at the collieries, and they will not be at the expense of making that stock; but when that stock is made and kept up, they will make use of it.

1801. Have you been a hewer?—Yes.

1802. Have you never in your life had brattices lying in your bord when you felt uncomfortable in the face of your work, and did not take the trouble of putting up the brattice?—I would always take the trouble to put it up, if it was necessary.

1803. Do not you remember, that sometimes you did not take the trouble to put up the very material which had been supplied to you?—No, I have no remembrance of anything of that kind; I recollect very well being nearly killed by an explosion from the want of brattice; I came out about three or four minutes before the explosive point was arrived at, and complained to the deputy, and when more brattice was put in and a door set at the bord end, the whole of the gas was cleared away in two hours, which had accumulated in about half an hour from first perceiving it, to fill the seam two feet high from the floor, and 10 yards from the face.

1804. Did you ever hear workmen complain of having too much air?—They will sometimes complain of the air being driven too heavily upon them when the place is first holed.

1805. Mr. *Stephenson.*] Although in some mines the amount of bratticing may be scanty, would you say there was a deficiency of bratticing, generally speaking, in the Newcastle or Durham coal fields?—Yes; I think they are all deficient, from what I have learned from the colliers.

1806. Did you experience a deficiency yourself when you were a workman?—A great deal.

1807. *Chairman.*] If an accident occurs, independent of the unfortunate circumstance of a great number of lives being sacrificed, is not the coalowner put to great expense?—Yes.

1808. Do not you think it would be some inducement to the coalowner to find sufficient materials for carrying on the workings properly, and avoiding danger?—It ought to do so, but it is not done.

1809. You have stated that you have heard complaints of having too much air. Is the reason of that because the candles sweal?—Yes.

1810. Do not you think that if a safety-lamp could be invented, which was secure in itself, and gave as much light or more light than a candle, that would obviate the difficulty; and that the workman could work in a better current of air than he could with a naked light?—Yes; a lamp of that kind would effect the purpose.

1811. Have you seen no lamps of that kind at present?—Yes; I have seen one or two.

1812. What lamp have you seen which has effected that object?—Dr. Clanny's lamp.

1813. Have you seen Dr. Glover's lamp also?—I have not seen it lighted.

1814. Have you seen a lamp which has been invented by Mr. Henderson, a workman?—Yes.

1815. Is that a good lamp?—I think it is as good as Dr. Clanny's, because it removes one objection which was made at the Committee of 1849, that a drop of water falling on Dr. Clanny's lamp glass would break it.

1816. Is not the weight an objection both to that lamp and to the lamp invented by Dr. Clanny?—I asked several workmen if they preferred the Clanny lamp.

1817. Which lamp, in your opinion, do the workmen prefer?—As far as they have a choice of employing different lamps, they prefer the Clanny lamp to the Davy.

1818. Mr. *Cayley.*] Have you seen Dr. Fife's lamp?—Yes.

1819. What do you think of his lamp?—I think it is a very good lamp.

1820. Do you think it is superior to any of the others?—By having a talc surrounding the glass, it removes the objection of the drop of water.

1821. Is it made of a finer gauze?—I think it is not; I have not examined it closely.

1822. *Chairman.*] Taking every precaution which could possibly be used to secure full and efficient ventilation of a mine, do you think that circumstances may exist in which it would be necessary to enforce the imperative use of the safety-lamp?—Yes.

1823. You think that an inspector should be empowered by the Legislature to enforce the use of safety-lamps?—Yes; I think he should have the power, where he sees danger, of enforcing the use of the safety-lamp.

1824. And therefore you think, that in addition to good ventilation, the use of the safety-lamp should sometimes be enforced by legislation?—Yes.

1825. Mr. *Cayley.*] What you want in reality is, sufficient ventilation?—Quite so.

1826. How do the workmen test the amount of ventilation?—They have no means of testing it, except by feeling its want.

1827. In what way do they feel it?—They want air to breathe when they are working.

1828. That comes from the heavy gas?—Yes.

1829. But the heavy gas is not the gas which would explode?—No.

1830. How do they test the presence of fiery gas?—They generally have a notion of its presence, if it is strong, by the smell.

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1831. They can smell the fiery gas?—Yes.

1832. Is not another test the lengthening of the flame of the lamp?—Yes; if they are employing a safety-lamp, or a candle, they can test it by that mode.

1833. Supposing the colliers found there was a large amount of gas constantly present when they were working, and that no steps were taken by the overmen or the viewers to diminish the quantity, do you think it would be desirable that the workmen should have some means of confidential communication with an inspector, so as to give him notice of the danger?—It is necessary that it should be so.

1834. How could you carry that out?—I believe it is not practicable to carry it out, inasmuch as the workmen feel alarmed by having their names exposed; and they hardly dare complain, lest they should lose their employment.

1835. *Chairman.*] Could not the workmen complain, through an authorised agent like yourself, and could not you, on receiving such a complaint, speak to the inspector, and by that means would it be known who was the man who had first made the complaint?—That has been done up to this time on frequent occasions.

1836. Has it been done with any good effect?—It has been done with very good effect at one colliery; but I will show you the way in which the employers attempted to learn the men's names who signed the document, and sent it to Sir George Grey, complaining of the colliery being in an unsafe state; six of the men's names were signed to it, and the master wished to find them out; he requested the inspector to give up the document, which he refused; to make sure work of it, he wrote this heading on a large sheet of paper, "We, the undersigned, are not the persons who sent our names to Sir George Grey complaining of the dangerous state of the colliery," and he asked every man, as he came in to get his money, to read it and sign it. It was only on account of the first men not being the actual parties, coming to prepare the others for it, that they went in and signed it, although they were actually the senders.

1837. Suppose the men had complained to you, and you had complained to the inspector, and the inspector in consequence of that complaint had gone to the colliery to observe whether it was in a dangerous state, how could the master of the colliery possibly know that any complaint had been sent to the inspector, unless the inspector had told him?—It depends on the confidence of the inspector.

1838. What is the general opinion of the workmen as to the verdicts of coroners' juries, when accidents occur in a mine?—They think them nearly a farce.

1839. Do they think that juries give wrong verdicts, or that the coroners do not perform their duties?—I believe their opinion is, that the coroners are anxious to do their duty, but that they have not competent jurymen.

1840. *Chairman.*] Do not you think it would be desirable that the Government inspectors, when they paid visits of inspection, should examine into the state of the lamps?—Yes.

1841. Do not you think that where safety-lamps are used, it should be imperative on the owner of a colliery to have one man always to clean the lamps, and if they are out of repair, to repair them?—I do.

1842. Do not you think that were safety-lamps are used, they should be locked?—Yes.

1843. Do you think the keys should never be entrusted to the workmen, but always to parties appointed by the overman of the mine, who should open the lamp when it was necessary?—Yes.

APPENDIX.

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APPENDIX.

Appendix, No. 1.

PAPER delivered in by *H. F. Mackworth*, Esq., and referred to in his Evidence, 16 June 1853.

INSTRUCTIONS and QUESTIONS relative to the Parliamentary Committee, now sitting to inquire into the Causes of Accidents in Coal Mines. Appendix, No. 1.

(Copy.)

Sir,

You are no doubt aware that I have given notice to revive the Committee on Accidents in Coal Mines. The Government has consented to its revival, but wish it deferred until the return of two of the Inspectors, who are now inquiring into the system of inspection adopted in foreign countries, and other matters connected with the working of mines. I think it right to inform you, that you will be required to give evidence before the Committee.

The subjects to which I beg leave to direct your attention, as being those on which information is required, will be ventilation by furnace, steam jet, or any other mode either in use or which may be suggested as an improvement to those now generally adopted.

The capacity and size of the air-ways, and the best modes of carrying the air through the workings to the upcast shaft, so as either entirely to clear the goaves of foul air, or to leave as little in them as possible, and to prevent what may remain from escaping into the workings, so as to cause accidents by explosions. The methods of supporting the roof and sides, so as to prevent as much as possible the recurrence of accidents from falling masses of materials. The best mode of winding the men up shafts, so as to lessen their risk by the breakage of ropes, chains, or parts of the winding machinery, and any other precautions you may think necessary, to lessen the number of accidents which occur.

Your attention is also directed to the safety lamp; and your opinion is also solicited as to whether you agree with the Report of the Committee of 1852 on that subject; and whether, since that, any new discovery has been made which will tend to the improvement of the safety lamp.

Your opinion will also be required as to the system of inspection; whether or not you approve of having Government Inspectors; and if you do, whether or not you think the present number are sufficient, and if not, what increase you would suggest.

You will observe that in coroners' verdicts, in at least 99 cases out of 100, a verdict of "accidental death" is returned. This may be accounted for by the state of the law, which gives no discretion to coroners' juries, who are either obliged to return a verdict of accidental death, or manslaughter.

Your opinion is requested as to whether some law should not be made enabling a jury to assess damages in case of carelessness, or to assimilate the law to that of Scotland.

Your opinion is also desired as to whether power should not be given to magistrates or to the Secretary of State, on the representation of the Inspectors, to levy fines on the owners of collieries, where necessary precautions are not taken to prevent accidents; and also upon the workmen who uncover their safety lamps in dangerous situations, or commit any other reckless act, so as to endanger the lives of their fellow-workmen.

You will also probably be invited to give an opinion as to what system can be adopted, which would work best, for the establishment of schools for the children of workmen, and funds for the relief of themselves in case of sickness, and of the widows and orphans of those who may meet their death through accidents.

Any other information you may feel disposed to tender, that may enable the Committee to come to a conclusion on the several subjects connected with their inquiry, will be acceptable.

The Committee will probably assemble about the end of May; but due notice will of course be given to you as to the day on which your attendance is required. I shall be glad if, before that time, you will furnish me with a draft of the evidence that you may wish to tender, that I may have no difficulty in proceeding with your examination when you are called upon.

I am, &c.
(signed) *E. J. Hutchins.*

25, Eaton-square, London,
3 May 1853.

Appendix, No. 1.

TABULAR VIEW of the Number of ACCIDENTS causing DEATH in the COAL MINES of *Great Britain*, in 1851 and 1852.

Counties comprised in Districts.	In Shafts.	From Falls of Roof.	From Explosions of Fire Damp.	Miscellaneous.	TOTALS.	YEARS.
Lancashire, Cheshire, North Wales, Stafford, Worcester, Shropshire	101	152	55	37	345	1851
Ditto	87	177	51	31	346	1852
Scotland	28	45	2	9	84	1851
Ditto	19	23	5	10	57	1852
Northumberland, Durham, Cumberland	15	31	10	39	95	1851
Ditto	23	44	10	39	116	1852
York, Derby, Nottingham, Warwick	19	29	17	10	75	1851
Ditto	26	33	11	20	90	1852
Monmouth, Gloucester, Somerset, and South Wales	22	50	14	13	99	1851
Ditto	20	56	14	22	112	1852
TOTAL in Great Britain	185	307	98	108	698	1851
Ditto	175	333	91	122	721	1852

TABULAR VIEW of the LIVES LOST in the COAL MINES of *Great Britain*, in the Years 1851 and 1852.

Counties comprised in Districts.	In Shafts.	From Falls of Roof.	From Explosions of Fire Damp.	Miscellaneous.	TOTALS.	YEARS.
Lancashire, Cheshire, North Wales, Stafford, Worcester, Shropshire	114	159	111	42	426	1851
Ditto	103	190	116	39	448	1852
Scotland	28	52	62	8	150	1851
Ditto	20	23	5	13	61	1852
Northumberland, Durham, Cumberland	15	32	57	39	143	1851
Ditto	28	44	38	43	153	1852
Yorkshire, Derbyshire, Nottingham, Warwick	19	30	76	10	135	1851
Ditto	28	35	22	23	108	1852
Monmouth, Gloucester, Somerset, and South Wales	41	54	15	20	130	1851
Ditto	26	57	83	50	216	1852
TOTAL in Great Britain	217	327	321	119	984	1851
Ditto	205	349	264	168	986	1852

Note.—The serious explosions in 1851, were:

15 March	Nitshill	61	Killed.
20 December	Warren Vale	52	„
22 „	Ince	13	„
	TOTAL	126	Killed.

The serious explosions in 1852, were:

24 April	Norley Hall	12	Killed.
6 May	Hebburn	22	„
10 „	Dyffryn	65	„
20 „	Coppull	36	„
22 December	Elsecar	10	„
	TOTAL	145	Killed.

Appendix, No. 1.

Hainault, Belgium.—List of Accidents.

Province of Hainault, comprising the Two Districts of *Mons* and *Charleroi*.

	1849.		1850.		1851.		1852.	
	Accidents.	Killed.	Accidents.	Killed.	Accidents.	Killed.	Accidents.	Killed.
Descending by ropes or chains	9	12	8	21 (*a*)	7	6	14	22
Descending by ladders	7	4	3	2	4	1	6	5
In the shafts from other causes	8	9	14	9	12	10	18	16
Falls of roof and coal	31	19	49	32	46	40	41	33
Explosions of fire damp	7	6	3	83 (*b*)	2	5	7	106 (*c*)
Inundations	2	—	- -	—	1	—	1	2
Explosions of powder in blasting	2	1	1	—	2	—	3	—
Suffocated	2	3	1	1	2	2	—	—
Accidents on inclined planes	14	2	16	8	8	2	—	—
Accidents from divers causes	10	5	14	4	5	2	26	21
	92	61	109	160	89	68	116	205

	Accidents.	Killed.	Wounded.
The average Number of accidents for the 10 years before 1850 were	114	71	93

(*a*) Includes 12 men killed by the breakage of a wire rope at the colliery Masse St. François.
(*b*) Includes 76 men killed at Quaregnon.
(*c*) Includes 69 men killed at Long Terne Ferrand, near Elouge, and 35 at Longterne Trischer.

	1850.	1851.	
Number of winding pits at work	244	228	
Number of workmen employed	34,800	35,468	
Quantity of coal	4,420,761	4,753,186	Tons.

Average number of deaths in 1851 and 1852, which is much above the average } 3·88 per annum per 1,000 workmen.

Average in whole of Belgium in 1851, is 2·2 per 1,000; in 1852, is 4·6 per 1,000; from 1845 to 1850, 2·82 per 1,000.

Comparative Loss of Life in Coal Mines per 10,000 Persons employed in and on the Mines per Annum on 460,000 Persons in England, 256,760 in Belgium, 73,275 in Westphalia.

	Falls of Roof.	Explosions of Fire Damp.	Breakage of Ropes and Chains.	Ladders.	In Shafts.	Blasting.	Inundations.	Miscellaneous.	Totals.
Great Britain: 1851 and 1852	14·4	12·4	- -	9·0	- -	- -	6·1	- -	41 9
Westphalia (Grafshaft Mark): Years 1841 to 1852	10·0	1·0	- -	4·0	- -	- -	1·0	- -	16·0
Belgium: 1846 to 1850	9·4	5·4	3·2	0·8	3·6	0·6	0·2	5·0	28·2

Appendix, No. 1.

General Law concerning the Ventilation, Lighting, and employment of Gunpowder, in the operations of Mining, especially in Coal Mines subject to Fire Damp.

[Report to the King.

Sire, 1 March 1850.

The presence of carburetted hydrogen gas (fire damp) in coal-mines has hitherto produced the most lamentable effects on the mortality of the workmen. The statistical tables show that the majority of these great catastrophes in our mines must be attributed to the ignition of this dangerous gas. The determining cause of these explosions is to be found principally in vicious methods of ventilation, in the imperfection of the means for lighting, and on the careless or ignorant use of powder in blasting mineral substances. It is there that the evil exists; it is there that the remedy must be applied. To prevent the recurrence of fresh calamities, the provincial councils, in unison with the Government, have sanctioned several rules of special police. But these arrangements not emanating from a single source, have not that similarity and general character which are required to render the application equally useful in all our coal basins; in other respects they are also wanting. In order to introduce uniformity of action in the administration, and better to caution the workmen against the perils by which they are menaced in their occupations, my department has charged a special commission to lay down a project for a public law concerning ventilation, lighting, and using powder in mining works, especially in fire damp mines.

This commission, composed of Government engineers and the directors of important collieries, offers every guarantee for the defence of the various interests engaged in the working of mines. The project which I have the honour to submit to your Majesty is the work of the commission. Most of the arrangements it encloses are in operation in the provincial regulations; their salutary effects have been already confirmed by practice; the rules hereby added are with the object of extending the application to all the coal basins. Several new arrangements guaranteed by experience and science, are intended to increase the safety of the workmen, in neutralising or removing the causes of danger. Finally, this law, in the manner in which it has been constructed, as well as by the protective measure which it holds sacred, and the similarity and unity of purpose which it presents, appears to me to respond entirely to the intentions of Government. The Article 67 of the Constitution confers on the chief of the State the power to make laws and bye-laws, when necessary, for the execution of the fundamental laws. The project hereto annexed being but the development and the putting in operation of the arrangements of police authorised by the law of 21 April 1810, and the decree of the 3d January 1813, the right of sanctioning it and rendering it obligatory, belongs essentially to the exercise of the constitutional prerogative of your Majesty. I venture to think, Sire, that if my proposals receive your Majesty's approbation, working miners and all persons who are interested in their welfare, will receive this law as a new evidence of the anxiety of the Government for the amelioration of the labouring class.]

Leopold, &c.,

Having seen the law of the 21st April 1810, and the Imperial decree of the 3d January 1813, on mines:

Having reviewed our orders of 11th May 1840, 11th August 1841, and 29th June 1844, approving of the bye-laws concerning ventilation, lighting, and the use of powder in the mines of Liege and of Hainault, and particularly in the fire damp mines:

Having seen Article 67 of the Constitution, and Article 85 of the Provincial Law of the 30th April 1836:

Considering that it is useful to generalise certain measures, and to introduce into the administrative action unity of purpose, and every uniformity compatible with the particular circumstances of mining in various localities:

On the proposal of our Minister of Public Works, we have commanded, and do command:

Chapter I.—Exploitations in General.

Article 1. In every subterranean exploitation all the points of works to which the workmen can gain access to, shall be rendered healthy and safe by an active and regular current of pure air.

The velocity and abundance of this current, as well as the size of the galleries, which must be easily accessible in all their parts, shall be everywhere regulated according to the number of the workmen, the extent of the works, and the natural emanations from the mines.

2. The ventilation shall be effected and uniformly sustained by efficacious means, exempt from all danger.

3. Every current of air seriously vitiated by an admixture of inflammable or deleterious gas, shall be carefully separated from every working place and frequented road. The extent of the working faces shall be so from time to time limited, as to protect the workmen placed in the return current from the hurtful effects of too great a deterioration in the air.

4. The

4. The stoppings or gobbings established, either to support the rocks or to separate the tramways from the corresponding ventilation galleries, shall be everywhere rendered as firm, as well-maintained, and as impermeable as possible.

5. These gobbings shall advance to within a short distance of the working faces, so as to hinder, towards those points, the slackening of the current and the stagnation of hurtful gases.

6. The works shall be so disposed as to avoid the use of many doors to direct or divide the current of air.

Every door intended to divide the ventilation shall be furnished with a trap, the opening of which can be regulated as required. The use of double or treble doors, conveniently placed, is imperative in roads where they have to be frequently opened for the service of the mine.

Chapter II.—Fire Damp Mines.

Ventilation.

7. In fire damp mines the mining shall proceed, as far as possible, by successive stages, worked in descending order.

With the exception of cases authorised by the administration, the whole and every part of the works shall be so disposed as never to cause the descent of air more or less charged with inflammable gases.

8. The air shall escape by one pit, appointed for this purpose, and isolated from the other pits by a sufficient thickness of rock.

The exhaustion of the air shall be produced either by mechanical means, or by heating, to the exclusion of lamps or furnaces fed by the air returning from the mine. At the surface, every precaution shall be taken to protect every furnace from the gas which issues from the mine.

9. The intake and return air passages shall be separated by ribs, sufficiently thick to preclude damage being caused by an explosion.

10.

Lighting.

11. The use of safety lamps, of the kind admitted by the Administration of Mines, is compulsory in fire damp mines.

12. Safety lamps shall be locked; they shall be kept at the office, where special workmen shall be employed to examine, clean, and maintain them every day in good condition.

13. At the time of descending, the lamp is to be given to each workman, and he is required to assure himself that it is locked.

14. He is expressly forbidden to open the lamps in the works. Those which go out shall be sent back either to the surface, or to some appointed place in the mine, where they shall be inspected, re-lighted, and locked, by men specially appointed to this charge.

15. When fire damp may appear in a working place or gallery, in sufficient quantity to produce a continued lengthening of the flame of the lamps, the work shall be immediately stopped, until this danger has ceased.

Use of Gunpowder.

16. The use of gunpowder for blasting coal in fire damp seams is forbidden, with those exceptions which are permitted by the Administration.

17. The employment of this aid is only allowed for works in the rock, under the reserve expressed in the following conditions:—

1st. No substance is to be employed for lighting the match, which is capable of burning with flame.

2d. Not to fire the shot, until by inspection of the flame of the lamp it has been carefully ascertained that there is no inflammable gas in that part of the works.

3d. To appoint for the performance of this duty, and that of lighting the charge, master workmen, or experienced miners previously exercised in this duty.

Chapter III.

18. There shall be in every exploitation, especially in fire damp mines, besides the overmen, a certain number of miners (overlookers) specially entrusted with the details of the daily supervision of the means of ventilation and lighting.

The number of overlookers shall be fixed by the engineer of mines, according to the extent of the works, the nature and abundance of the gases, and the degree of security which the system of ventilation presents.

Appendix, No. 1.

19. These miners, as well as the blast lighter, shall be designated by the director on the register of the control of the workmen.

20. These miners in their capacity of overlookers, each in his appointed district shall—

A. Visit with care the air courses, and cause them to be maintained in good condition ; not allow the whole or part of a gang of workmen to enter the works until he has ascertained that the air there is pure, that the ventilation is sufficiently active, that all things are in order, and that there exists no kind of danger for the workman which is capable of being removed.

B. Maintain during all working hours a strict supervision in the working faces and most frequented roads in all that concerns the management of lamps, in the getting and removal of materials, in the opening of doors, in a word, in everything essentially connected with the efficiency of the ventilation, and the security of lights.

C. Inform against the authors of every breach of the rules of prudence and discipline, in order that they may be punished ; and denounce in a similar manner every workman who may carry a pipe, matches, or any materials for striking a light in works where the employment of safety lamps is compulsory.

D. Stop the work in every part where fire damp is seen, and direct with prudence the retreat of the workmen.

21. The engineers of mines shall exercise a strict control over the preceding arrangements; they shall assist, when required, the managers with their advice; they shall inscribe in such a case their recommendations in a register specially kept for this purpose in the office of the works, and which shall be substituted, in this instance, for the register of progress mentioned in the Article 6, of the decree of 3d January 1813. At each visit they shall inscribe on this register the result of their observations.

22. When they are called upon the permanent deputations of the Provincial Council can grant delays or conditional dispensations to secure the rigorous fulfilment of the preceding arrangements.

23. Any breach of the above regulations shall be prosecuted and tried conformably to the 10th Title of the Law 21st April 1810, on Mines and Quarries.

24. Our Minister of Public Works is charged with the carrying out of the present regulations of general administration.

Appendix, No. 2.

PAPER delivered in by Mr. *Herbert Francis Mackworth.*

COMPARATIVE ABSTRACT of Experiments on the Economy of Four Kinds of Fans, by Mr. *Jochams.*

NATURE OF THE RESULTS OF THE EXPERIMENTS.	KIND OF VENTILATING FAN EMPLOYED.				
	Fabry's.	Letoret's.	Pasquet's.	Motte's.	
Velocity of pistons, in feet per minute	161	236	207	195	
Depression of water-gauge, in inches	1·96	1·65	1·37	0·94	
Quantity of air extracted, in cubic feet per minute	19,758	13,540	16,002	10,932	
Motive power transmitted to the ventilator, in horse-power	10·37	11·37	9·56	6·50	
Useful effect obtained, in ditto	6·22	3·58	3·52	1·65	
Proportion of useful effect to power transmitted	0·60	0·32	0·37	0·25	
Coal consumed, per horse-power per hour, in lbs.	12·2	12·87	15·9	17·4	
Water evaporated, per horse-power expended, per hour, in lbs.	73·4	77·2	95·4	104·7	
Coal consumed, per horse-power utilized, per hour, in lbs.	21·5	43·9	45·1	73·6	
Water evaporated, per horse-power utilized, per hour, in lbs.	129	263·3	270·5	441·4	
Cost of first establishment complete, in £.	403*l.* 13*s.* 355*l.* 13*s.*	252*l.*	195*l.*	164*l.* 9*s.*	Without boilers.
Cost of first establishment, per horse-power of useful effect, in £.	48 *l.* 42*s.* 8*s.*	45*l.* 2*s.*	50*l.* 7*s.*	74*l.* 13*s.*	
Cost of the ventilator alone, in £.	220*l.* 176*l.*	24*l.*	43*l.* 16*s.*	42*l.* 17*s.*	
Cost of the ventilator, per horse-power of useful effect, in £.	26*l.* 5*s.* 20*l.* 19*s.*	4*l.* 6*s.*	11*l.* 7*s.*	19*l.* 4*s.*	
Cost of working, per year, in £.	129*l.* 17*s.*	203*l.* 3*s.*	143*l.*	128*l.* 3*s.*	
Cost of working, per horse-power of useful effect, in £. per year	26*l.* 10*s.*	56*l.* 8*s.*	58*l.* 17*s.*	57*l.* 10*s.*	
Maximum quantity of air extracted, in cubic feet	25,590	26,256 *	21,982	15,397	* The ventilator not exhausting from the mine.
Corresponding depression of water-gauge, in inches	1·81	1·34	1·10	0·90	
Maximum depression, in inches	3·38	2·04	1·77	1·10	
Maximum useful effect, in horse-power	8·39	5·61	3·87	2·23	
Proportion of maximum useful effect to power expended	0·66	0·60	0·41	0·37	

ABSTRACT of Five Experiments on Fabry's Pneumatic Wheels, by Monsieur *Jochams*, Engineer of Mines.

	Velocity of Piston of Steam-engine, in Feet, per Minute.	Water-gauge, near the Ventilator, in Inches.	Cubic Feet of Air Exhausted per Minute.	Moving Force transmitted to the Ventilator, in Horse-power.	Work Utilized, in Horse-power.	Proportion of Useful Effect to Power expended.	Coal Consumed (per Hour, per Horse-power Expended), in Lbs.	Coal Consumed (per Hour, per Horse-power Utilized), in Lbs.	Weight of Water Evaporated (per Horse-power Expended per Hour), in Lbs.	Weight of Water Evaporated (per Horse-power, Utilized, per Hour), in Lbs.
Fabry's Ventilator -	128	0·88	20,330	5·37	2·81	·52	14·43	27·6	86·6	165·7
Ditto - -	173	1·6	21,500	10·37	5·41	·52	12·10	23·2	72·6	139·2
Ditto - -	149·5	2·4	15,817	8·95	5·97	·67	11·4	17·2	68·9	120·6
Ditto - -	142	3·0	14,776	11·21	6·97	·62	11·20	18·04	67·19	108·24
Ditto - -	112	3·44	8,912	8·46	4·82	·57	11·28	19·82	67·71	118·93

Note.—They are quite new, fitted up in the best manner, with horizontal cylinders and direct action.

Struve's Ventilator at Eaglesbush	204	1·55	16,950	5·85	4·14	·70	15·90	22·46	89·9	127·1

Note.—The engine is second-hand, the steam passages contracted, and the ventilator beam is attached to the engine by single link chains, 60 feet long.

COMPARATIVE TABLE of Cost of Eight Kinds of Ventilating Machines, according to Monsieur *Ponson*.

KIND OF VENTILATOR.	Cost of Ventilator, Engine, &c.	Cost of the same per Horse-power, Utilized.	Cost of the Ventilator alone.	Cost of same, per Horse-power, Utilized.	Working Expenses, Annual.	Cost of Working, per Horse-power, per Year.
	£.	£.	£.	£.	£.	£.
Cylinder and piston machines - - -	1,020	210	140	29	263	54
Single-acting airometers - - - -	514	138	195	53	193	40
Curved vane fans - - - - -	198	184	45	42	136	126
Straight vane fans - - - - -	254	65	24	6	203	53
Motte's screw - - - - - -	166	180	43	46	128	136
Pasquet's spiral - - - - - -	195	59	44	13	143	43
Windmill ventilator (Lesoinne's) - - -	192	218	50	57	141	161
Fabry's pneumatic wheels - - - -	355	54	136	27	130	20

Appendix, No. 3.

PAPER delivered in by Mr. *Herbert Francis Mackworth.*

EXPERIMENTS ON VENTILATORS.

Appendix, No. 3.

1. *Motte's Pneumatic Screw.*—The first kind applied to the ventilation of mines in 1839 at Monceau Fontaine, near Charleroi, was awarded a premium by the Academy of Sciences. It is a double-blade Archimedian screw, 7 ft. 4 ½ in. in diameter, 3 ft. 7 in. in length, which is half the pitch of the blades. It revolves in a horizontal cylinder cased with masonry, and it is set in motion by a strap, which multiplies the velocity 7·2 times. At the outer end of the screw is an iron disc 5 ft. 7 in. in diameter, to prevent any reaction of air in the central part of the screw. The annular space for the escape of the air is therefore 11 inches wide. *Vide* Plan (A.)

The downcast shaft of the mine is 315 yards deep, area 61 square feet; the upcast shaft is 238 yards deep, and 22 square feet in area. There are three main currents or splits of air in the workings, and one sub-division. The sum of the length of the four splits is 8,660 yards; the average area 14 ½ square feet. When the pressure of the steam in the boiler was 38 lbs. the number of revolutions of the screw was 274 per minute, the water-gauge ·92 inch, the quantity of air exhausted 15,396 cubic feet per minute. The work utilised on the air was therefore 2·23 horse power. The work expended on the strap was 5·98 horse power, the ratio between these, being that of useful effect to power expended, is 37 per cent.

With the same power applied and the same number of revolutions, the resistance was increased to 1·12 inch water-gauge, the ventilation fell to 9,030 cubic feet per minute, and the ratio of useful effect to 27 per cent.

It has worked up to 1·8 inch water-gauge.

2. *Lesoinne's Windmill Ventilator.*—Similar in construction to Biram's Anemometer, was first constructed on a large scale in 1845. *Vide* Plan (B.)

At the Grand Bac Colliery, near Liege, the ventilator is 8 ft. 8 in. in diameter, and nine inches wide in the direction of the axis. Smeaton's angles for the direction of the sails of windmills have been adopted, and the vanes at the circumference are inclined at an angle of seven degrees to the diameter, and near the centre at angle of 19°. It is set in motion by a strap which multiplies four times. The steam-engine has a cylinder 7 ½ in. diameter, and a stroke of 22 ½ inches.

The downcast shaft is 273 yards deep, 70 square feet area; the upcast 35 square feet in area. The average length of the air-courses 2,200 yards, and area 30 square feet.

When the steam was at 30 lbs. in the boiler, there were 162 revolutions; the quantity of air 15,900 cubic feet per minute; the water-gauge ½ inch.

Another of these ventilators, of nearly the same dimensions, with 201 revolutions, gave 19,300 cubic feet per minute, with ·52 inch water-gauge, and the highest water-gauge ever obtained by Lesoinne's ventilator is ·56 inch.

3. *Pasquet's Spiral Ventilator* consists of a screw with six threads of sheet iron wrapped round a cylinder 5 feet 7 inches diameter, which is closed by a disc; the external diameter of the spirals is 8 feet 2 inches; the breadth of each thread or vane is therefore 15 ½ inches in the direction of the radius. Each vane passes one-sixth round the circle, and the amount of pitch, or the breadth of ventilator in direction of radius is 8 inches. Each aperture is 8 inches by 15 ½ inches, and the sum of the apertures for the escape of the air 5·16 square feet in area. *Vide* Plans (B.) & (C.)

The diameter of the cylinder of the steam engine is 12 ½ inches, stroke 2 feet. By wheel gearing, the velocity is multiplied 6·6 times.

At Moulin à Vent Pit, La Reunion Colliery, at Montigny-sur-Sambre, the downcast pit is 68 square feet in area, the upcast 26 square feet in area, and the depth of each is 317 yards.

There are three main splits, two of which are again subdivided; the total length of all the splits is 1,346 yards, and the average area 25 square feet. When the steam in the boiler was at 31 lbs., and the engine making 50 strokes, the spiral 330 revolutions per minute, the water-gauge indicated 1·8 inch; the quantity of air was 12,720 cubic feet;

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the work utilised 3·60 horse power; the work communicated to the axis of the machine 10·87 horse power; therefore the ratio of useful effect to power was 33 per cent.

When no air was allowed to pass through the ventilator, with a pressure of 32 lbs. in the boiler, there were 306 revolutions per minute, and the exhaustion upon the air measured by 2·4 inches water-gauge. The best effect is at about one inch of water-gauge.

Vide Plan (A.)

4. *Letoret's Inclined Vane Fan* has four flat vanes fixed at an angle of from 110° to 130° to radial arms. The air enters on each side at the centre, and passes out either at one square aperture, or the whole circumference is left open.

At Grande Veine, at Elouge, near Mons, the outside diameter of the vanes is 9 feet 2 inches; of the inner, and of the circular aperture for the entrance of the air, 4 feet 6 inches; the inclination of vanes to radius 120°; the vanes are 3 feet 3 inches high, and 3 feet 11 inches wide. The motion is given by a strap, which multiplies four times. The horizontal cylinder is 12½ inches diameter, the stroke 2 feet 0½ inch, and the steam is cut off at 4/5.

The downcast pit is 308 yards deep, 9 feet in diameter. The upcast (ladder) pit 279 yards deep, 5 feet 9 inches diameter.

There are two main splits of air, and four minor; the total length of all the splits is 1,083 yards; average section 30 square feet. The two seams worked are 30 inches and 48 inches thick. The quantity of air extracted was 14,350 cubic feet, at $1\frac{6}{10}$ inch water-gauge, at 240 revolutions per minute of the fan. The useful effect was 28 per cent.

When one of the galleries was closed the fan made 228 revolutions; the air exhausted was 7,650 cubic feet per minute, at 2 inches water-gauge; the useful effect was 2·46 horse power; the moving force 12·18 horse power; the useful effect 20 per cent.

It has worked up to 2·32 inches water-gauge.

The ventilator and engine, without boiler, cost 160*l.*; the building, 68*l.*; the culvert and connexion with pit, 54*l.*; total, 280*l.*

Vide Plan (C.)

5. *Combes' Curved Vane Fan.*—The air enters on one or both sides of the centre, and is expelled from the circumference by from three to six curved vanes.

At Grand Hornu, near Mons, the diameter of the outer ends of the vanes was four feet eight inches of the inner, and of the aperture for the entrance of the air, three feet seven inches. The vanes, which were three in number, formed an angle of 15 degrees with the inner circle, and ended as tangents to the outer circumference. The axis was vertical, the upper side closed by a disc, the centre of the lower side was open to the shaft, and a ring or collar of sheet iron, five inches in depth, dipped into water to prevent the loss of air.

At 570 revolutions per minute, 5,870 cubic feet of air were exhausted at ·86 water-gauge, and 0·78 horse-power were utilised; 4·96 horse-power were transmitted to the fan, and therefore the ratio of useful effect was 16 per cent.

With an improved fan of this kind, and with apertures on each side, as much as 26 to 29 per cent. of useful effect have been obtained by Monsieur Glépin. With 516 revolutions 8,460 cubic feet of air were obtained at a drag of ·84 inch water-guage.

Vide Plan (D.)

6. *Lemielle's Feathering Fan.*—It is on a horizontal axis, the exterior being closed with masonry, except the bottom, which is in connexion with the mine, and the top, which is open for the escape of the air.

That at Pit St. Henri, at Baicmont, has been erected three months, and is the only one in Belgium. It consists of a central six-sided prism, each side four feet six inches wide, and ten feet two inches long (which is the width of the fan); to the angles are attached flaps, four feet six inches wide, working on hinges. The flaps are opened and shut by connecting rods, working on an axis which is 18 inches excentric to the first-mentioned. The fan is constructed of sheet-iron.

The steam-engine, which is in bad order, has 12-inch cylinder, and 38-inch stroke; the motion is communicated by gearing, but not multiplied. Steam in boiler at 30 lbs. Revolutions, 17 per minute. Water-gauge, 1·32 inches, said to give 20,000 cubic feet of air per minute. At 24 revolutions the water-gauge is said to rise to two-and-a-half inches. One which was worked at Seraing, at from 40 to 80 revolutions, gave a water-gauge of four inches.

The experiments on this machine are not as yet sufficient to determine its advantages, but like that of Fabry, it has a slow motion, in which it will possess a great advantage over the other fans, although its friction will be greater in the working parts.

Vide Plan (D.)

7. *Fabry's Pneumatic Wheels.*—First erected in 1845, at Mambourg; were exhibited at the Great Exhibition in 1851. They consist of two wheels, each with three projections or cogs, the surfaces of which so work together, that little or no air can descend between them; and each wheel, in the upward portion of its revolution, drives out the air from the mine. The centres of the wheels are six feet six inches apart; they are six feet six inches long, measuring along the axis. The length of each tooth or cog from the centre is five feet seven inches. They are made either of sheet iron or of wood. The steam-engine has a 12-inch cylinder, and two feet stroke.

The downcast pit is 440 yards deep, and 67 square feet area. The upcast 330 yards deep, and 27 square feet area.

There-

There are three main splits of air, one of which is divided into six minor splits; the average length of each split is 560 yards; average area, 26 square feet. When the pressure in the boiler was 41 lbs., the number of strokes and revolutions, 48 per minute; the water-gauge 1·8 inch. The quantity of air was 24,400 cubic feet; the power utilised, 6·92 horse-power. The horse-power expended on the machine, 12·45. The ratio of useful effect was therefore 55½ per cent.

First Cost:	£.
12-horse engine, boiler and ventilator	420
Erecting engine-house, chimney, culvert and machinery	197
	617

Working Expenses:	£.	s.	d.
Working and repairs, per annum	47	16	–
Coal	61	16	–
	109	12	–

It is the intention of Mr. Fabry to simplify and reduce the cost of his machine, by substituting two teeth for three, and five ventilators of this kind are already ordered. This is of a similar kind to that patented by Mr. George Jones, of Lionel Foundry, Birmingham, but which as yet has only been applied to blowing cupolas and forges.

8. *Cylinder and Piston Ventilator.*—That at Hainchamps Pit, near Liege, has been at work for 18 years. It is composed of two wooden cylinders, open at the top, the bottom fitted with valves; they are 11 feet 7 inches in diameter. The pistons are suspended to the opposite extremity of a beam; they are fitted with valves which open upwards; the length of stroke is six feet two inches, and soap and water are used to lubricate the cylinder. *Vide* Plan (E.)

There are 20 valves in each piston and cylinder bottom. The steam cylinder is fixed over one end of the beam; the stroke, six feet two inches; diameter, 13 inches. With steam in boiler at 41 lbs., the number of strokes was 14, the quantity of air 17,000 cubic feet per minute; the water-gauge indicated 4·2 inches area, 1·8 inch maximum expansion and compression respectively, and a mean resistance represented by three inches of water. The work utilised on the air was, therefore, 7·98 horse power, and taking 50 per cent. off the power of the engine transmitted to the beam, the ratio of useful effect is 56 per cent.

9. *Plunging Bells, or Single-acting Airometers.*—The original and rude form of this machine has been very long known in Cornwall, under the name of the Duck Machine, as well as in the Hartz and other mining districts. It was improved by Mr. A. de Vaux, and erected in 1842 at Mairhaies, near Seraing. It consists of two airometers (similar to gasometers), 11 feet 6 in. in diameter, dipping into water, and having an alternative movement of 5 feet. *Vide* Plans (E.) & (F.)

With 12 ½ strokes per minute, the volume of air due to the motion of the machine was 12,890 cubic feet; but the quantity actually passed was only 11,500 cubic feet, owing to leakage and injurious space, &c. The water-gauge varied from 1·96 expansion to ·6 compression. The mean was 1·28 inches.

The work utilised on the air was 2·32 horse power, and the useful effect was 45 per cent. of the power transmitted.

General Remarks.—The ventilators of Combes, Lesoinne, and Motte are not suited to overcome a resistance of more than 5 lbs. per square foot (the second one not half so much); but they exhaust a certain quantity of air at a small cost of outlay and maintenance. Letoret's and Pasquet's ventilators have the additional advantage of working advantageously up to a drag of 10 lbs. per square foot; but the high velocities, as well as certain peculiarities in the use of all the above machines, causes a very considerable loss of power. In this last respect, Lemielle and Fabry's machine possesses a superiority, as well as in their capability of overcoming a resistance amounting to 15 lbs. per square foot. Although in the cylinder and piston machine an almost unlimited drag can be overcome, it is liable to many objections, amongst which are friction, resistance in valves, inadequacy for large ventilations. The single acting airometers, with the same advantage, present fewer defects. The air, however, enters and passes out only below the airometers. When made according to the patent of Mr. W. P. Struvé, of Swansea, with a casing over the airometer, so that the air passes in and out both above and below, it becomes double acting, and a great advantage is obtained. By the use of large valve-areas, each of the four sets of valves being equal to half the area of an airometer, and by working at a slow motion, a power, effect, and economy, exceeding that of all the other machines which I have named, can be obtained. With either two machines, or four, it is competent to produce the largest ventilation required in any mine in England, and to overcome, with economy, at least double the resistance which the ventilation of any mine at present offers. It is capable of

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more expansive action to meet emergencies, and more regulated control, than ventilation by rarefaction.

According to Monsieur Ponson, the ratio of useful effect to transmitted power of eight of the ventilating machines, is as follows:—

Fabry's pneumatic wheels	53 per cent.
Single-acting airometers	48 „
Pasquet's spiral	26 „
Lesoinne's windmill ventilator	25 „
Letoret's fan	24 „
Cylinder exhausting machine	23 „
Motte's pneumatic screw	19 „
Curved vane fan	15 „

To do the same amount of work as the Espérance cylinder ventilator, viz., 17,000 cubic feet of air exhausted at 3 in. water-gauge, would require 138 jets on Mehu's plan ¼ in. diameter, tubes or cylinders 8 in. diameter, and 3 ft. 3 in. long, and 150-horse boiler power, with a steam pressure of 75 lbs.

Cost.

	£.	s.	d.
Six boilers, each 30 horse power (one being a reserve)	922	–	–
138 Wrought iron tubes	30	–	–
138 Copper pipes, ¼ inch diameter, with cock to each	50	–	–
Cast iron tubes to convey the steam	33	–	–
Steam-engine of seven or eight horse power, for feeding boilers	224	–	–
Earthwork and masonry of ventilating gallery	5	10	–
Construction of furnaces and a brick chimney, 43 yards in height and two yards internal diameter	1,124	–	–
Erecting engine and contingencies	80	–	–
£.	2,468	–	–

Working Expenses.

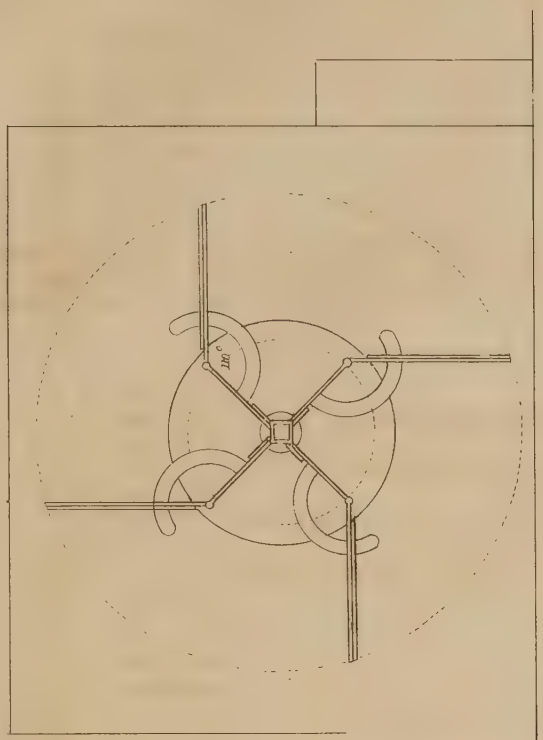
	£.	s.	d.
Salaries: six firemen, two enginemen, per year	233	10	–
8,758 tons of coal	2,070	–	–
158 lbs. of neats-foot oil	3	10	–
106 lbs. of purified oil	2	10	–
106 lbs. of grease	2	–	–
185 lbs. of waste and hemp	4	–	–
Maintenance and repairs	24	–	–
£.	2,339	–	–

According to the experiments of Mr. Glépin.

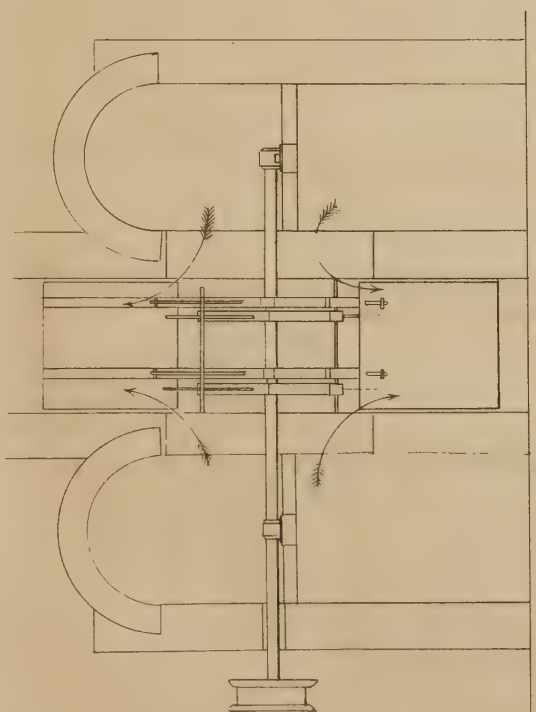
Comparative Economy of Furnace (underground and above), Steam Jet Ventilators, according to Mr. Glépin.

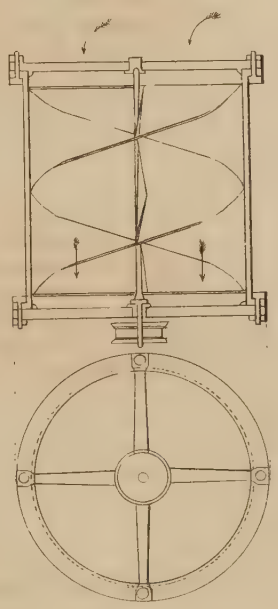
NAME OF APPARATUS.	Moving Power transmitted.	Moving Power Useful Effect.
Exhausting engines, reciprocating motion (Mairhaies)	100	25 to 40
Ventilator of Mr. Combes	100	27 to 29
Screw of Mr. Motte	100	20 to 24
Ventilator with straight vanes of M. Letoret	100	16 to 20
Ventilator of M. Pasquet	100	10 and 24
Steam jet in ventilating shaft	100	6·8
Steam jet of M. Pelletan	100	6 and 7
Ventilator with straight vanes in sheet iron	100	5
Furnace at the surface, with a chimney 45 to 55 yards high	100	4 to 5·5
Apparatus of M. Mehu (steam jet)	100	1·8 to 5·5
Steam-pipe in the ventilating shaft (exhausting)	100	3·5
Ventilating chimney, the furnace working a high-pressure engine	100	0.8
Ditto ditto ordinary steam engine	100	0·5

PLAN (A.)



Letoret's Ventilator Fan.





Motte's Pneumatic Screw.

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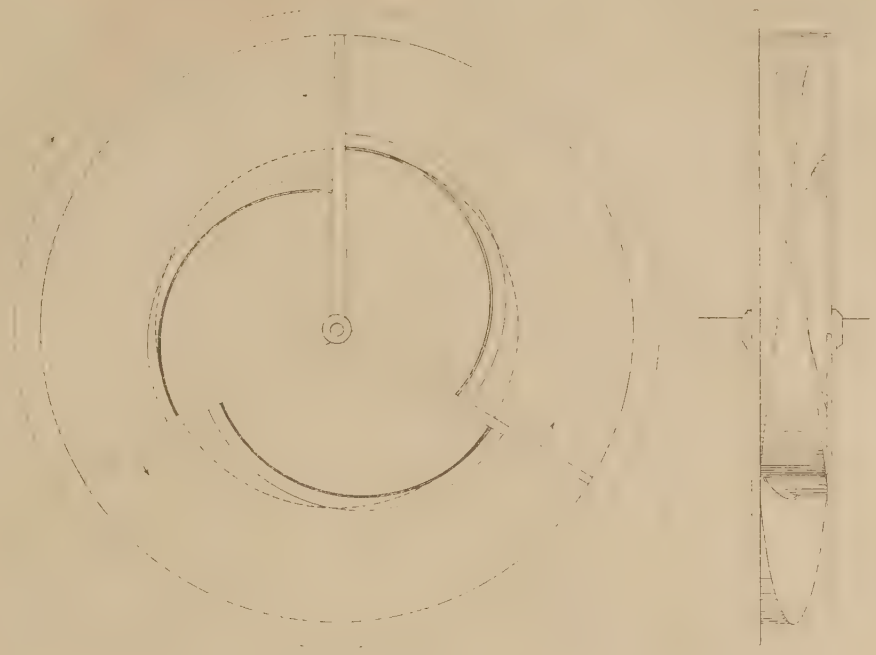
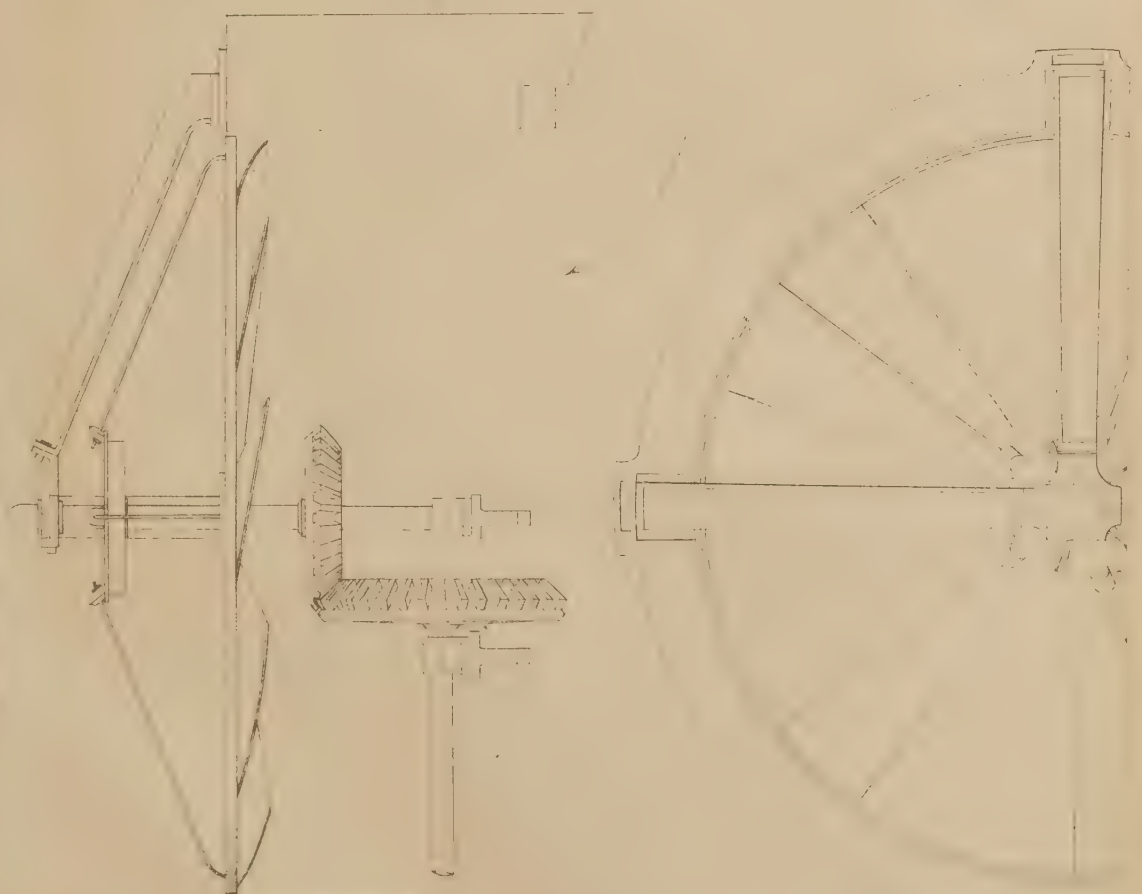
PLAN 3.

Pasquet's Ventilator



Lesueurs Windmill Ventilator



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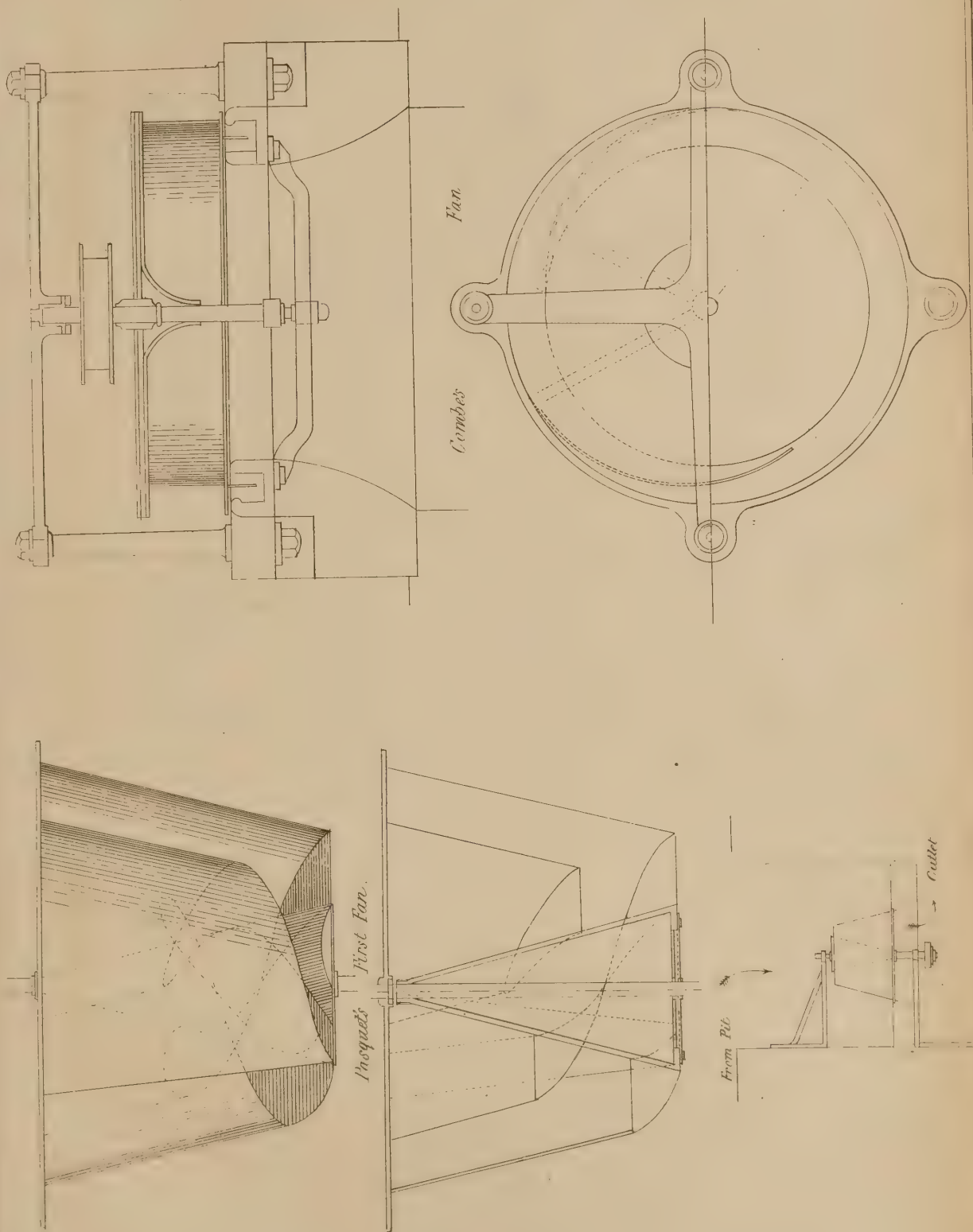
PLAN (C.)



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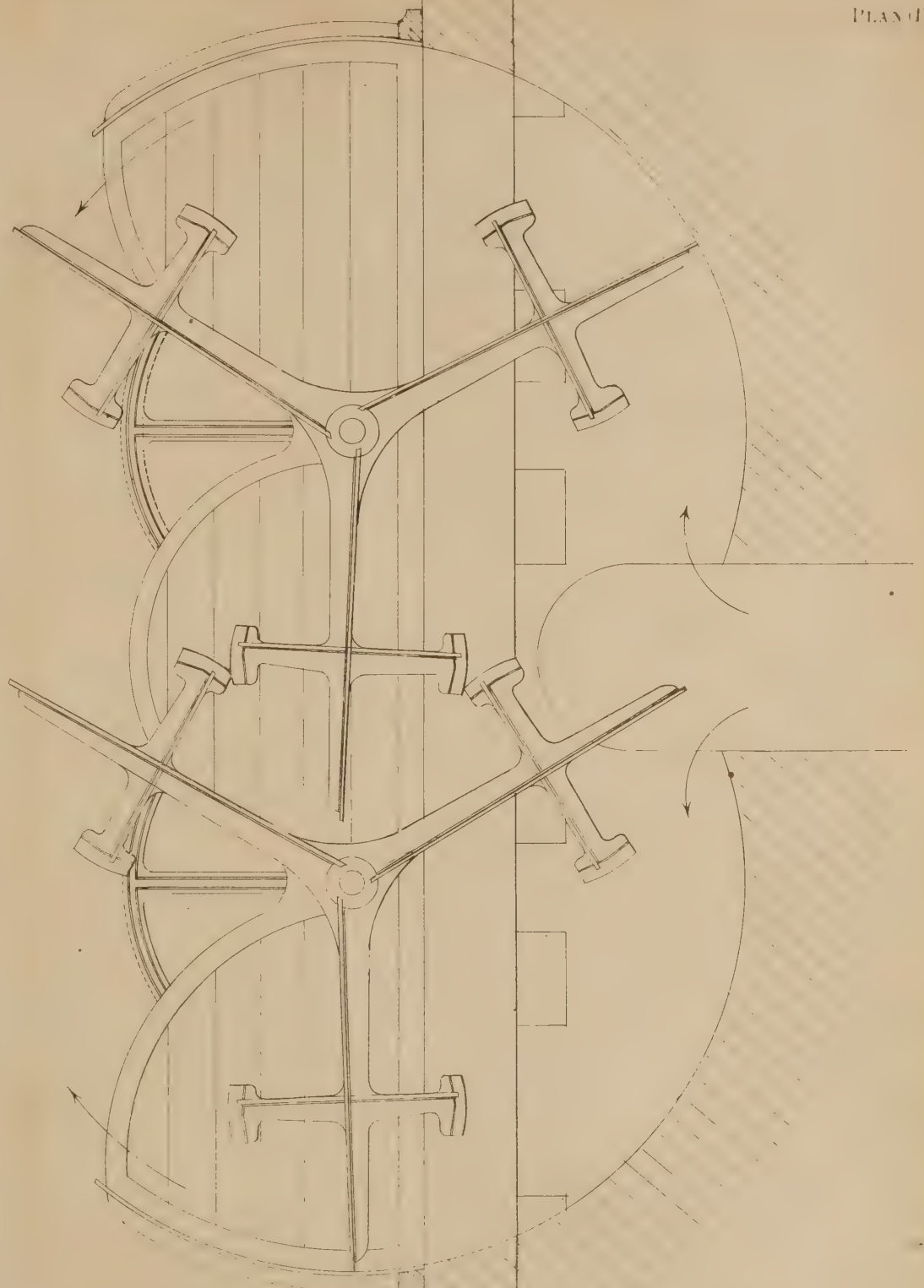
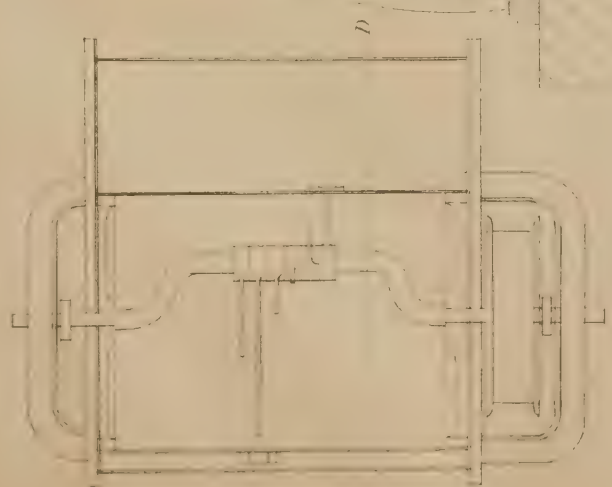
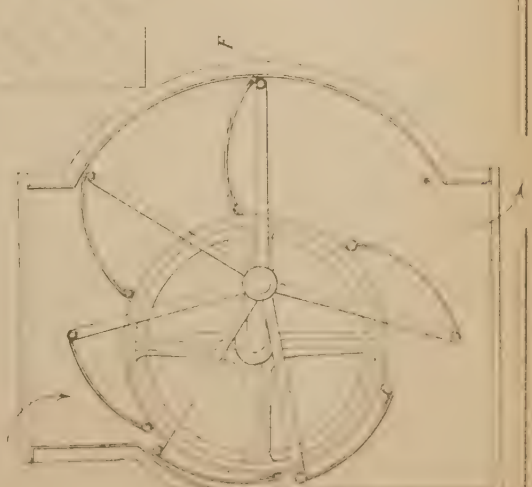
PLAN (D.)



Fabry's Ventilator in Wood.





Lamelle's feathering Fan.

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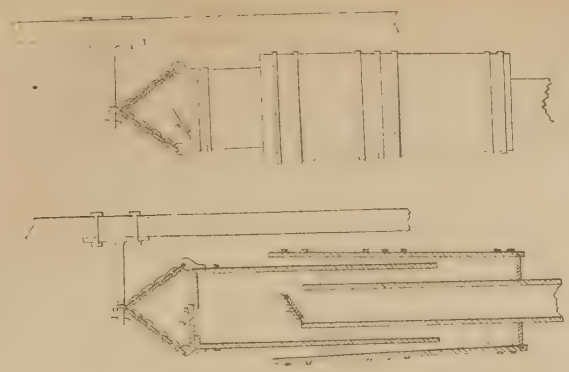
PLAN (E.)



Exhausting Fall - Dook Machine used in the Hartz.

Wooden Cylinder Ventilator.

N° 691. Ordered, by The House of Commons to be Printed, 30th June 1835.
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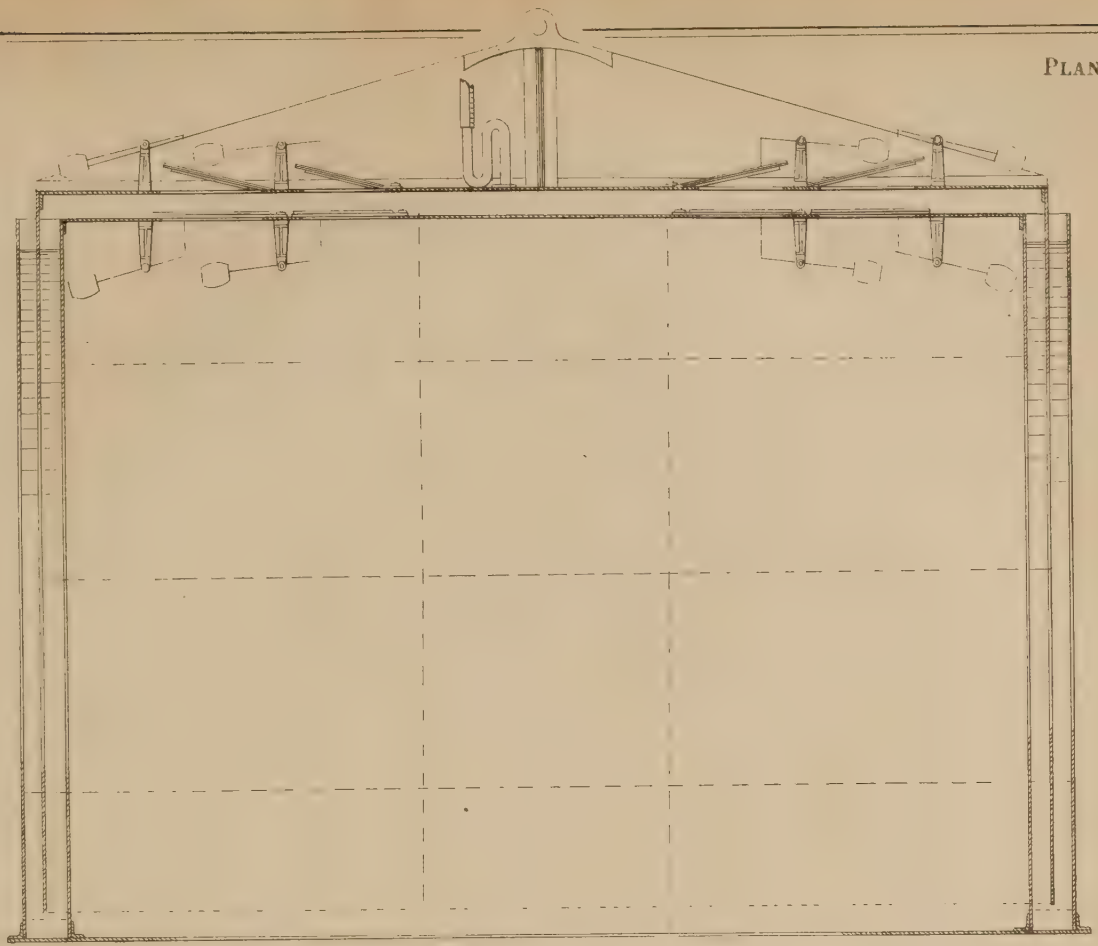
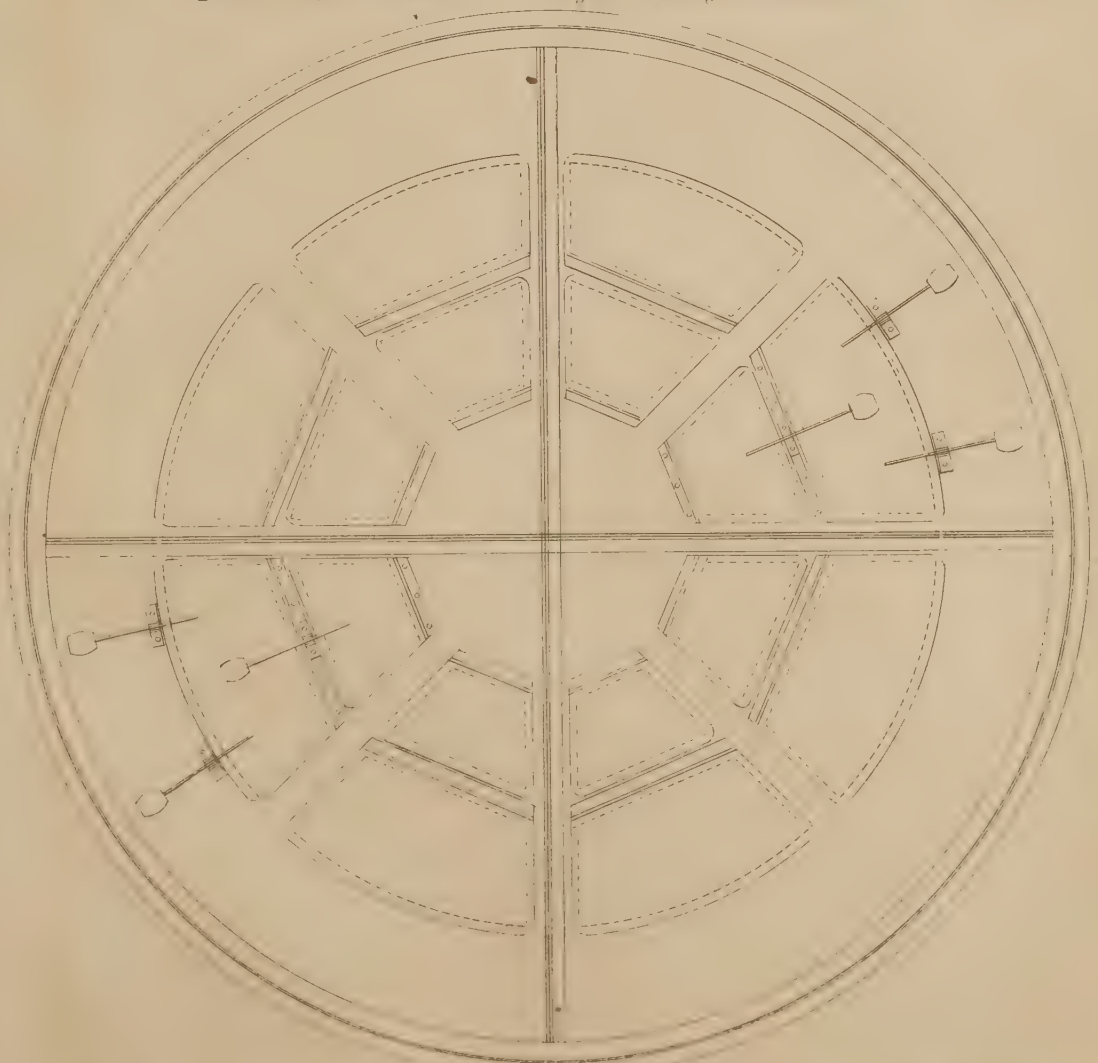
PLAN (F.)



Plan and Section of Single Acting Anemometers



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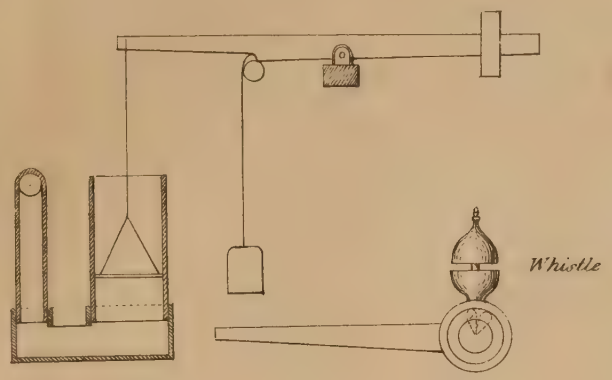
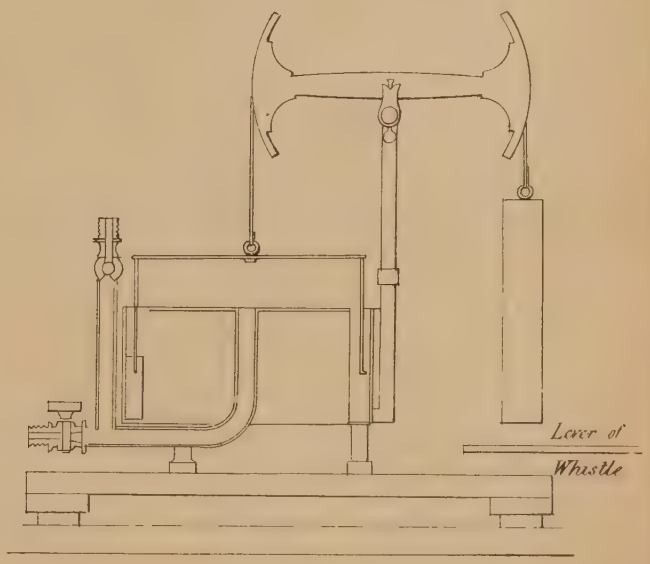
PLAN (G.)

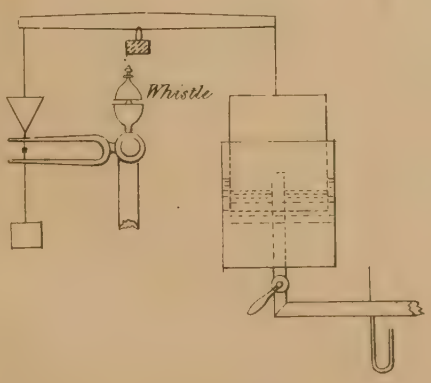
Ventilator Danger Signal.



Patent Ventilator's Danger Signal.



Ventilator Danger Signal.



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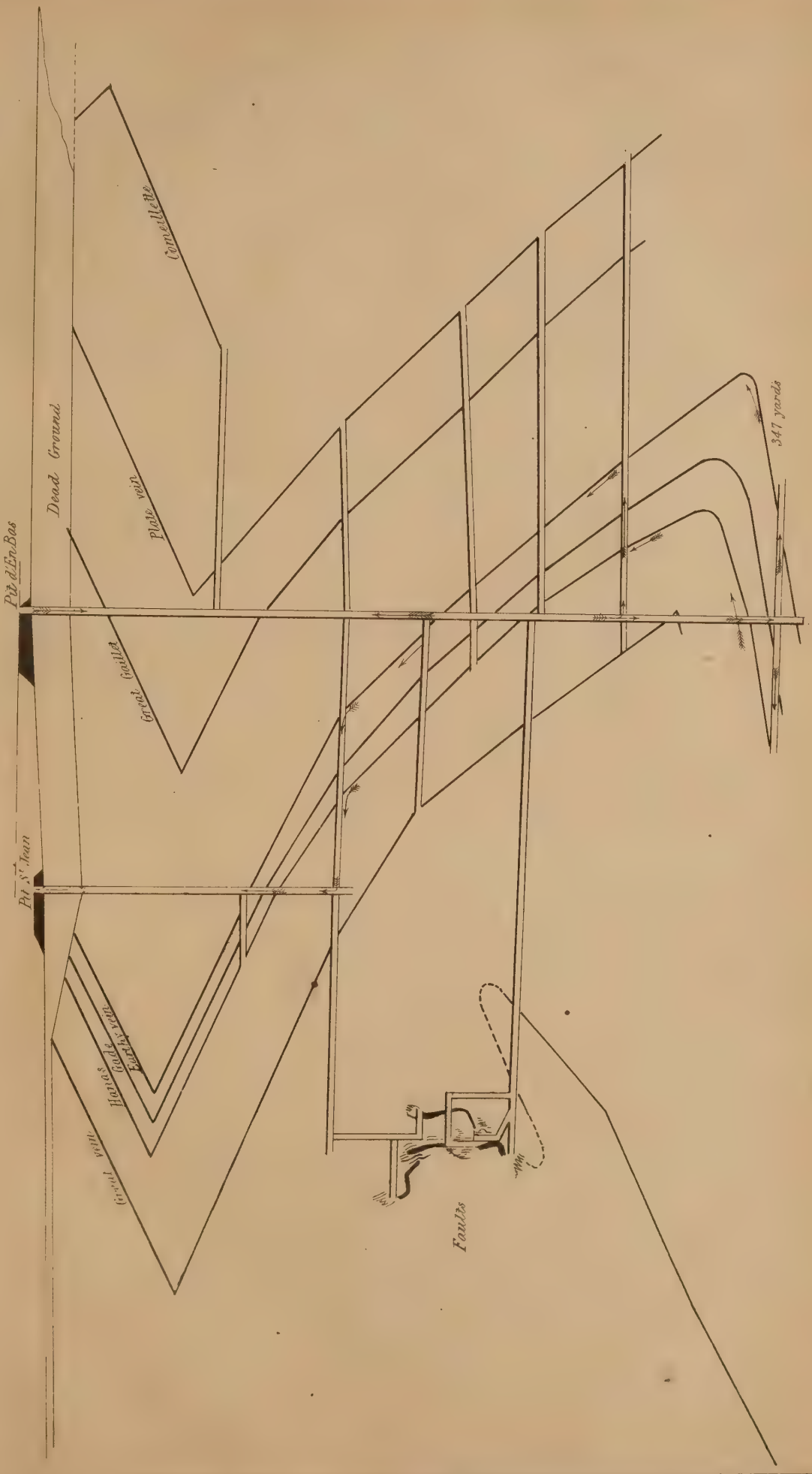

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Appendix, No. 3.

COMPARATIVE first Cost of Establishment of various Machines at per Horse Power.

	£.	s.	d.
Underground furnace, utilising 0·8 of the total heat developed	6	10	–
Furnaces of Anzin, ditto ditto	17	10	–
Furnace in the mine	27	–	–
Furnaces of Anzin	70	–	–
Ventilator of M. Combes	180	–	–
Ventilator of M. Pasquet	201	–	–
Screw of M. Motte	201	–	–
Ventilator of M. Letoret	244	–	–
Steam jets of M. Pelletan	247	–	–
Cylinder pumping engine	267	–	–
Single acting aerometer	286	–	–
Apparatus of M. Mehu (steam jets)	314	–	–
Ventilator with straight vanes in sheet iron	617	–	–
Furnace at the surface	823	–	–

COMPARATIVE Cost of Working, at per Horse Power of Useful Effect, per Annum.

Underground furnace, utilising 0·8 of the heat developed	49 *l.*
Reciprocating blowing engines	52 *l.* to 56 *l.*
Ventilator of M. Combes	60 *l.*
„ M. Motte	70 *l.*
„ M. Pasquet	70 *l.*
„ M. Letoret	92 *l.* 10 *s.*
Underground furnace, utilising 0·25 of the heat developed	150 *l.*
Jet of M. Pelletan	225 *l.*
Apparatus of M. Mehu	286 *l.*
Ventilator with straight vanes	330 *l.*
Furnace near the surface	616 *l.*

FIRST REPORT

FROM THE

SELECT COMMITTEE

ON

ACCIDENTS IN COAL MINES;

WITH THE

MINUTES OF EVIDENCE,

AND

APPENDIX.

Ordered, by The House of Commons, *to be Printed,*
30 *June* 1853.

[*Price* 4*s.* 6*d.*]

691.

Under 24 *oz.*

SECOND

REPORT

FROM THE

SELECT COMMITTEE

ON

ACCIDENTS IN COAL MINES;

WITH THE

MINUTES OF EVIDENCE,

AND APPENDIX.

Ordered, by The House of Commons, *to be Printed,*
11 *July* 1853.

Martis, 31° *die Maii*, 1853.

Ordered, That a Select Committee be appointed to inquire into the Causes of the numerous Accidents in Coal Mines, with a view of suggesting the best Means for their Prevention.

Jovis, 2° *die Junii*, 1853.

Committee nominated of,—

Mr. Hutchins.
Mr. Fitzroy.
Mr. Ingham.
Mr. Hussey Vivian.
Mr. Baird.
Mr. Cumming Bruce.
Mr. Cayley.
Colonel Pennant.
Mr. Stephenson.
Mr. Mostyn.
Viscount Goderich.
Mr. Farrer.
Mr. Child.
Mr. Henry Austin Bruce.
Mr. Cobbett.

Ordered, That the Committee have power to send for Persons, Papers, and Records.

Ordered, That Five be the Quorum of the Committee.

Jovis, 9° *die Junii*, 1853.

Ordered, That Viscount Goderich be discharged from further attendance on the Committee, and that Mr. Locke be added thereto.

Lunæ, 27° *die Junii*, 1853.

Ordered, That the Committee have power to Report the Minutes of Evidence taken before them from time to time to The House.

REPORT - - - - - - - - - - - - - p. iii
MINUTES OF EVIDENCE - - - - - - - - - - p. 1
APPENDIX - - - - - - - - - - - - p. 82

SECOND REPORT.

THE SELECT COMMITTEE appointed to inquire into the Causes of the numerous ACCIDENTS in COAL MINES, with a view of suggesting the best Means for their Prevention, and who were empowered to Report from time to time to The House,—

HAVE made further progress in the Matters to them referred, and have agreed to Report the Minutes of Evidence taken before them.

11 *July* 1853.

LIST OF WITNESSES.

Jovis, 30° *die Junii*, 1853.

Mr. Martin Jude - - - - - - - - p. 1
Mr. Robert Henderson - - - - - - - - p. 19

Lunæ, 4° *die Julii*, 1853.

Mr. David Swallow - - - - - - - - p. 28
Mr. William Gray - - - - - - - - p. 51

Jovis, 7° *die Julii*, 1853.

Mr. Allan Tetlow - - - - - - - - p. 60
Nicholas Wood, Esq. - - - - - - - - p. 73

MINUTES OF EVIDENCE.

Jovis, 30° die Junii, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Stephenson.
Mr. Cayley.	Mr. Mostyn.
Mr. Cobbett.	Mr. Fitzroy.
Mr. Child.	Mr. Hussey Vivian.
Mr. Locke.	

E. J. HUTCHINS, Esq., IN THE CHAIR.

Mr. *Martin Jude*, called in; and further Examined

Mr. *M. Jude.*

30 June 1853.

1844. Mr. *Cobbett.*] WHO is the principal man, or manager in a mine; what do you call him in your part of the country?—Head viewer.

1845. How many are there in a mine?—After the head viewer, there is an under viewer.

1846. And the next man is an overman?—Yes.

1847. How many overmen are there in a mine generally?—One fore overman, and one back overman.

1848. What are the next people?—The deputies come in next, deputy overmen.

1849. How many of those are there?—The number ranges according to the size of the pit, three or four, five or six sometimes.

1850. What are the next men?—Those are all the officers that carry on the works of a colliery.

1851. Are there any waste men?—Yes.

1852. What are the waste men?—They attend to the ventilation part.

1853. Those are the persons then who have to manage the ventilation?—Chiefly.

1854. How many of those are generally in a mine?—They have been very much reduced lately; there are very few collieries that have more than two or three in each pit.

1855. Are they in number according to the size of the pit?—I think that would be so, and the nature of the seam of coal.

1856. Do you know how many there are according to the quantity of coal raised in a pit?—I cannot say whether there is any principle of that kind acted on or not; I think it will be according to the fiery nature of the seam.

1857. Are there men called firemen?—They are known by that term in Lancashire and other counties, but not in Northumberland and Durham.

1858. Have you described the principal men in the pit?—Yes.

1859. What are the next, the working people?—Coal hewers.

1860. Those are the people who get the coal?—Yes.

1861. What are the next?—The putters.

1862. The hewers and putters are working people?—Yes.

1863. Are there others to take care of the road?—Yes, there are some parties appointed for that purpose; one or two in each pit, according to the size and dimensions.

1864. You said the last time the Committee met, that what was wanted principally was ventilation, and that every man should have a certain quantity of air supplied to him?—Yes; I should have said a sufficient quantity.

1865. You did not say how much?—No, I could not mention that exactly.

Mr. *M. Judc.*

30 June 1853.

1866. Your opinion is, that inspection is the principal mode by which the working men could be seen to have the sufficient quantity of air that you speak of?—Yes, I am fully persuaded that a proper system of inspection will ensure that.

1867. You spoke of an inspector visiting the men once a month?—Yes.

1868. By visiting once a month, could the inspector ascertain how far the men had been supplied, between the time he visited the mine and his last visit, with a sufficient quantity of air?—No, he could not ascertain as to any particular deficiency that might ensue in that period.

1869. Must it not be known then by inquiry of the persons who had been working during that time?—Quite so.

1870. So that the inspector would be the person to whom the working miner would have to complain, if he had complaints to make?—Yes.

1871. You said something in your last examination about the miners being afraid to make complaints, did you not?—Yes.

1872. Of whom would he be afraid?—He is afraid of losing his employment from that colliery.

1873. From what person?—The head viewer.

1874. In point of fact, do you consider inspection a matter of great importance as an appeal for the working men?—Yes; but I consider it of greater importance that working men should be attended to without those appeals being made. Intimidation still hangs over him, as the inspector would generally be accompanied by the overman or the under-viewer when making his visits, consequently he durst not speak in their presence what he ought to have said to the inspector individually.

1875. Mr. *Locke.*] Then I understand you rather to suggest, that it would be better to have this inspection made by the owners of the collieries than by a Government inspector?—No.

1876. How would you remedy the present defect, namely, of intimidation and fear, if the inspector continues to go with the overman through the pit?—I can hardly prescribe any remedy for that; it always will get out, some way or other, the fact of his having communicated to the inspector.

1877. If you want to have good ventilation in a mine, and you want to have the workmen protected, could that be done by any means by the owners of the collieries themselves, so as to prevent a man being subject to the suspicion of having communicated to the inspector?—I cannot see how he can escape being suspected, for I know a case or two which illustrate that very strongly. At one colliery in the county of Durham, near Newcastle, I was informed by one person that his district of the pit was very badly ventilated, and dangerous. He informed the inspector, and the inspector communicated to the head viewer, a few days afterwards, that he would be there to visit it on a certain day some days hence. He went, but previous to his going, eight or ten men were set to work to remedy this defect in the ventilation, and the man who gave the information to me informed me afterwards, that all the brattices were taken from the district he worked in to another part of the pit, and efficiently ventilated that part, and that man had to leave the colliery subsequently, although no names were ever given up.

1878. Do you attribute that entirely to the fact of his having made that communication to you?—I think they had got a suspicion that he was the man. They did not send him away from the colliery; they take another plan; they give a man less wages for working; they have many means at their command if they have a strong suspicion of a man.

1879. Is it your opinion that that man was discharged for communicating that fact?—I would not like to say that.

1880. What do you mean by giving that evidence to this Committee, if you do not mean it to have some effect; you gave it as an illustration of intimidation?—The man himself gave it to me as his opinion, that he was suspected of giving that information to me.

1881. Had the man himself any means of ascertaining the truth of that suspicion of his own, from the facts which came to his knowledge?—Only by the behaviour of the overmen and the under agents towards him.

1882. Are you aware whether he was ever charged with having made such a communication to the inspector?—Never.

1883. Mr. *H. Vivian.*] How long had he been at work in the pit?—I think three or four years in that colliery.

1884. Mr. *Locke.*] How long did he continue to work afterwards?—A few months.

1885. Mr. *H. Vivian.*] What aged man was he?—About 30 to 35.

1886. Are you aware how many collieries he had been in before?—I cannot say precisely, but several I know of.

1887. He might have been considered, perhaps, as rather a wandering man than a steady workman attached to the colliery?—He does not come under that term; generally speaking, in the north, he comes under the term of a steady hard-working man, anxious to get on, and well liked by the generality of his masters.

1888. It is generally well known to viewers what men in each pit are inclined to raise difficulties, and what men are not?—Yes.

1889. And when they find difficulties of various kinds arise they are very apt to pick out those men who they think have been at the bottom of these disturbances, or these combinations of men, and so forth?—Yes.

1890. Were there other men at the same time that were offered less wages than they might consider they were fairly entitled to?—At that colliery there was no combination existing.

1891. I am not asking that; I am asking whether there were other men who might not have been placed in the same position as regards wages at that colliery?—No.

1892. You are positive that in that colliery there were no other men who were placed in the same position?—No other men.

1893. How many men were there?—One hundred and twenty, or thereabouts.

1894. You can undertake to say that no other man was called on to do any different description of work from that which he had been hitherto doing?—No.

1895. You can say out of 150 men no other man was changed?—No other man.

1896. Mr. *Locke.*] Where was that?—I would not like to specify, unless it was necessary. There are several cases continually occurring of the same description.

1897. *Chairman.*] Have you any objection to give the name of the colliery?—No particular objection.

1898. Then give the name?—Unsworth.

1899. Mr. *Locke.*] How long ago is it?—Verging on two years.

1900. Mr. *Child.*] Was this man directly discharged, or did he leave in consequence of his wages being lowered?—No, he left; he was not discharged.

1901. Mr. *H. Vivian.*] Were his wages lowered, or was it required of him to work in a district where he would not get so much wages?—That was just it.

1902. You are quite certain no other man out of the 150 was placed in the same condition?—No.

1903. Mr. *Child.*] Were no men working in the same department that he was working in changed at the same time?—None.

1904. Mr. *Locke.*] I understand you to say, that you think that, as one of the means of increasing the security of mines, there should be increased superintendence?—Yes.

1905. I understand you also to say, that that superintendence should be on the part of Government?—Yes.

1906. And I understand you also to say, that you did not think that extra Government superintendence would remove the difficulty which you have just now expressed about intimidation and fear of the workmen?—I think it would not.

1907. Then how would you lessen that difficulty of intimidation and fear on the part of the workmen; supposing you wanted to satisfy the mind of the workman that everything was done for him that could be done, what means would you suggest for the purpose of satisfying that large body of men?—I think that an efficient inspection would prevent the men from having to make any complaints whatever, and frequent visits of the inspectors would insure that the master must keep these pits in tolerable good order, or be visited by certain pains and penalties which the inspector should be empowered to inflict,

Mr. M. Jude.

30 June 1853.

and that would prevent the men having to make any appeals, and remove the cause of intimidation.

1908. That answer is rather different to a former one; I understood you to say, that increased inspection would not get rid of the intimidation and fear of the workmen; now I understand you to say, that you think that increased inspection would be so beneficial in its operation, as to render any complaints on the part of the workmen unnecessary?—I do think so.

1909. You think that increased inspection would so infuse energy into the viewers and persons connected with the ventilation as would ensure effective ventilation?—Yes.

1910. And render the complaints of the workmen less numerous, and perhaps destroy them altogether?—Yes.

1911. Now you said that the number of waste men had been considerably reduced of late?—Yes.

1912. Why have they been reduced of late?—I think it is owing to the introduction of the Davy lamp, or safety-lamps.

1913. That has been a long time introduced; when you said there had been a reduction in the number of waste men, during what number of years do you speak?—Previous to the introduction of the Davy lamp.

1914. Had you any experience in mines before the introduction of the Davy lamp?—I was just a boy, working at playing the steel mills, when the Davy lamp was introduced.

1915. When you said that the number of workmen had been reduced, you meant that they had been reduced since the introduction of the Davy lamp?—Yes.

1916. Do you suppose they have been reduced during the last five years?—I think not.

1917. *Chairman.*] You stated in your examination of the other day, that it was possible, provided you could have confidence in the inspector, that the workmen should communicate to you, and you should communicate to the inspector, that the works were in a dangerous state?—Yes.

1918. Do you adhere to that opinion?—Yes.

1919. Do you not think that the workmen would have greater confidence in an inspector than if a set of sub-inspectors were appointed?—The higher in standing and the higher in life the gentleman was who was appointed to inspect the mines, the greater confidence the workmen and yourself would have in him, that he would not betray any confidence you might impose on him?—I believe the workmen would have less confidence in a man who was not of their own class; a practical mining engineer.

1920. Suppose practical mining engineers could be found of the grade of the present inspectors, do you think an increased number of them would satisfy the workmen?—It would depend entirely upon their conduct.

1921. Do the present inspectors satisfy the workman?—The inspector for the north district does not.

1922. What is his name?—Matthias Dunn.

1923. In what respect does he fail to satisfy the workmen?—The principal reason they have is, that he sends word or gives notice to the owners when there is any complaint made, a few days before he comes to pay the visit.

1924. Does he at the same time name the parties who made the complaint? No, I think not.

1925. Your objection is, that the owner of the coal mine has sufficient time to put the mine in order before the inspector's visit?—Yes.

1926. Not that the confidence that the workmen repose in the inspector is betrayed?—No; it is rather the mode in which it is done.

1927. You are now alluding to a different subject; the point on which I wished to have your opinion was this, what description of inspectors would satisfy the workmen, and give them confidence in making the complaints to you, and you to the inspector, that their confidence should not be betrayed by the inspector?—I could not specify any particular description of persons who would give the most confidence, excepting that I think the workmen would much rather that they should be practical mining engineers.

1928. Do the workmen think Mr. Matthias Dunn a competent person to inspect mines?—Quite competent.

1929. They think him a scientific and practical mining engineer?—Yes.

1930. Mr. *Locke.*] That meets the view you expressed before, as to the qualifications that the miners would be satisfied with?—Yes.

1931. Your objection to Mr. Matthias Dunn is simply that he communicates with the master of the colliery before he makes his inspection?—Quite so.

1932. In any other respect do the miners in the north of England raise any objections to Mr. Matthias Dunn's qualifications?—None at all.

1933. *Chairman.*] Do they not believe that Mr. Dunn's visits have always been beneficial, and that the mines have been put in good order after he has inspected, or in better order?—They have generally been so; they have expressed an opinion that there has been much good done by the inspector's visits, but they are so few and far between, that the pit lapses into the original condition before long.

1934. Do you think the workmen would rather have the number of the inspectors of the present kind increased than have a class of men under them, and, of course, inferior to them?—I think they would prefer having sub-inspectors. They have expressed so in their petition to the House several times.

1935. Have you ever heard men state their reasons for coming to that opinion?—The principal reason that I have noticed is, that the sub-inspector being a young man, would be able to travel round into all the nooks and crevices, and find gas out if it was possible to be found.

1936. You state that you wish that a sub-inspector should visit each mine in the north of England, in your district, once a month?—Yes.

1937. Can you give the Committee any idea how many sub-inspectors it would take to perform that duty under the inspector?—About seven or eight.

1938. Are you speaking of the whole district over which Mr. Dunn presides?—Northumberland and Durham; eight sub-inspectors would be sufficient, under the control of Mr. Matthias Dunn, or any other chief inspector.

1939. Mr. *Locke.*] Are you now giving your own individual opinion, or your opinion as gathered from the wishes of the workmen?—My individual opinion is so, and many of the workmen have expressed themselves to me to that purport.

1940. At the same time, have any of those workmen expressed to you what their notion would be of the qualifications of the sub-inspectors?—Yes, they have done so frequently.

1941. Now, what is their notion of the qualifications of a sub-inspector?—Some of the most intelligent of the miners themselves.

1942. Then the miners think that the sub-inspectors should be taken from the class of practical miners?—Yes.

1943. Young intelligent men who have been working in the collieries themselves?—Yes.

1944. And consequently would know where those nooks and crevices were best to be met with?—Just that.

1945. Are you of opinion that the miners in the north would greatly prefer a sub-inspector from that class, than from the class of young men brought from school or college, who had no previous knowledge of mining?—They would very much prefer the former.

1946. *Chairman.*] Is it your own opinion that the owners and proprietors, and head viewers of coal mines, would have equal confidence in such a sub-inspector as the men you have described the workmen to prefer?—I believe young intelligent men could be found in the collieries who would have both the respect and confidence of the owners and workmen.

1947. Mr. *Cobbett.*] The Act which created the inspectors was passed in 1850?—Yes.

1948. You had no inspectors before?—No.

1949. Are the working people, so far as you know them, better satisfied with their state since the inspectors were created, or before; has it done good?—It has not given general satisfaction.

1950. The inspectors have not?—No.

1951. Have they done no good?—The good is so small, that it has not given general satisfaction.

1952. Still you are in favour of Government inspection?—Yes.

1953. Your only complaint is, that the inspection at present in existence is not perfect enough?—Not sufficiently extensive.

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1954. *Chairman.*] The number is not adequate?—No.

1955. Mr. *Cobbett.*] Does that arise from the fact that the number of inspectors is not large enough?—Entirely.

1956. So far as those inspectors have been able to inspect mines, they have given satisfaction?—Yes, at each of the different severe explosions; Washington, Killingworth, Hepburn, since the inspectors were appointed; the inspector's report states that there was an inadequate supply of air.

1957. And other mismanagement which led to those misfortunes and loss of life?—The men were perfectly satisfied with these reports; and there was an improvement immediately, after these lives were lost, in the conditions of these pits, but the inspectors cannot go back again for a length of time; the pits are worked on to the verge of danger, from want of proper and frequent inspection.

1958. Now, in saying what you have just said, do you consider that you are speaking the sentiments of the body of the working people in mines?—Yes.

1959. What means have you of knowing their sentiments?—We have a general communication; I am secretary of the Mining Association.

1960. How long have you been their secretary?—About ten years.

1961. Before that time you were a working miner?—Yes.

1962. *Chairman.*] Are their meetings connected with the association?—Yes.

1963. How often do they meet?—They meet once a month, by delegates.

1964. How many delegates are appointed for each number of men?—One from each colliery, principally.

1965. Those are selected by the miners themselves?—Yes.

1966. Are they generally the most intelligent of that class of men?—Invariably so.

1967. Mr. *Locke.*] Do you think that the working men would contribute anything towards the expense of these sub-inspectors if they had some little power in the nomination of them?—I think they would.

1968. Did it ever enter your mind to consider any proposition of that kind, namely, that the men should have some power in the nomination of the sub-inspectors, and that they should also contribute a part of the expense?—As regards the expense, that never did enter my mind, but the other has frequently passed through my mind.

1969. That is, the question of appointment?—Yes, and we have more than once got several parties to give adherence that Mr. Matthias Dunn should be the inspector of the whole district.

1970. *Chairman.*] You stated, in the commencement of your evidence, that the miners wished this Report of the Select Committee of 1852 to be carried out; do you mean that they wished every part of the Report to be carried out?—I believe they specify so in their petition.

1971. Do they agree about what are called refuge-stalls?—They do not understand that particularly.

1972. In your evidence, as on the notes, it says that the miners and yourself wish the whole of the Report of 1852 to be carried out; first of all, with regard to refuge stalls, do you think these refuge-stalls would be of any use to the miner to guard him from after-damp in the case of explosion?—I have not had an opportunity of examining that practically, or otherwise.

1973. Can you conceive it possible to carry air to these refuge-stalls in any way, so as to make them available to the workmen to stay in for any length of time, provided the pit was to become full of foul air?—There is a possibility.

1974. Describe how it could be done?—By placing proper valves, and making them air-tight.

1975. How would you get the air to the stall at all when the communication was cut off by the stoppings and doors, or other things being blown away?—The air is already supposed to be in the stall, and the miner enters there and breathes this as long as it lasts, till fresh air is brought to him.

1976. You would merely have these refuge-stalls filled with air, and closed with a valve that would render it air-tight, and the miner entering there would merely have to breathe the air that is in the stall at the time he entered it?—Yes.

1977. When that was exhausted, he would be deficient of air, and die?—Yes.

1978. What

1978. What size should these stalls be, supposing there were 30 or 40 men in them?—It would take an immense size for that number of men.

1979. You would keep the refuge-stall open at all times, so that a current of air could go through it at all times, except in case of explosion, when the valve would be shut down, and make it air-tight?—Yes.

1980. Looking at the question as a practical man, and a man acquainted with collieries, do you think it feasible or practicable that a number of men could support life for any length of time in these refuge-stalls?—It would depend entirely on the number of men, and the largeness of the stall, and the stall being filled with a sufficient quantity of air.

1981. You cannot state to the Committee what area of air would support a man for any given length of time?—No, I cannot.

1982. You have not looked into that?—No.

1983. Nor the miners themselves?—No.

1984. With regard to bore-holes of goaves, do you think it feasible, in your Northumberland pits, to bore down on a goaf, and clear the air beyond these bore-holes?—I think it is practicable to bore holes into the goaf.

1985. Do you think they would not be downcasts?—I cannot tell that.

1986. Do you not think, if you were to bore a hole down into the pit, and the furnace was drawing into the pit, they would be down-casts?—It is more than probable it would be so.

1987. Would not water go down with them?—It is probable it would.

1988. Would not there be a difficulty in keeping them open?—A great difficulty.

1989. Are these bore-holes a plan that you, as a practical man, would recommend for clearing these goaves of foul air?—No, I would not recommend them.

1990. Then I suppose we may take your answer, with regard to this Report of 1852, to be that the workmen merely mean the general principles recommended by the Committee to be carried out?—Entirely so; I think they embodied the chief of them in the petition.

1991. Mr. *Locke*.] There is one in this petition, in which they pray that the qualifications of the managers and officers of mines shall be inquired into by some proper tribunal?—Yes.

1992. That, I see, is made a strong point of in this petition?—Yes.

1993. Can you suggest to this Committee who you would appoint for the purpose of making the examination as to the fitness of the officers of mines?—I think a Board might be formed of three or four of the principal mining engineers of the country.

1994. From your experience, how would you propose or recommend to this Committee that a Board should be formed for the purpose of examining into the qualifications of the officers for managing collieries?—Three or four of these principal mining engineers might form such a Board for examining them; a proper tribunal for examining them should be established.

1995. Would that be satisfactory to the miners?—I think it would.

1996. *Chairman*.] Would they prefer a Board of that kind to any Government Board?—Yes.

1997. Would you have all the officers of a colliery so appointed?—Yes.

1998. Generally speaking, from your own experience, do you think that the officers of a colliery now in the management of mines are deficient of the qualifications that are requisite?—Generally so.

1999. Taking the principal viewer, what you call the chief viewer, are they not generally a superior class of men in the north of England?—They are indeed.

2000. Perhaps superior to almost any viewers in any other part of the kingdom?—I cannot state that.

2001. You do not know of your own knowledge any class of men in mining, in any other parts of the country, superior to them in intelligence and experience?—I do not.

2002. What you call the under viewer, or the managing viewer, are they generally of the same class, or are they deficient in the proper qualifications?—They are of a different class, because the head viewers all serve their time or apprenticeship to the trade, and none are allowed to be head viewers except they go through this process. The under viewers are taken from the most intel-

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ligent of the workmen; probably those who have gone through all the stages from a deputy and overman to an under viewer.

2003. From your own experience as connected with the workmen, what is your opinion generally, without specifying individuals, of the qualifications and fitness of the general class of under viewers?—Many of them are very good and well qualified; others are not so.

2004. You said, if I understood your answer to a former question, that you should prefer these sub-inspectors to be taken from young men in the mines who have had some previous knowledge of mining operations?—Yes; ten years at least.

2005. Supposing that that be a good qualification for a sub-inspector, one may reasonably conclude that it is a good qualification, or a good experience for an under viewer?—So it is.

2006. Still I understand you to say that, notwithstanding that previous experience, you do not find the under viewers are so intelligent and fit as you think they should be?—Not generally so.

2007. You say there are some, in your judgment, unfit for it?—Quite unfit.

2008. Can you give the Committee any means of judging how that unfitness arises; if they have had the experience, in what way are they unfit for this position?—Many of them do not attend to their duties; they drink with the overmen and deputies, and, when the under viewer drinks, all the others must follow, as a matter of course.

2009. It is a sort of moral unfitness?—Yes.

2010. Is that extensive in the north of England?—Not very.

2011. Has it decreased or increased of late years?—Decreased very much.

2012. Is it decreasing still?—I think so.

2013. Now, going from the under viewers to the overmen, are the overmen, in your opinion, a well qualified class of men?—Not generally so.

2014. How are they; what school are they taken from?—Generally in the stage of progress as deputies.

2015. From the mining body?—Yes.

2016. The most intelligent miners?—Not the most intelligent.

2017. They are taken from miners?—Yes.

2018. Perhaps your complaint is, that they are not taken from the most intelligent class?—Yes.

2019. Do you think that is a school from which overmen should be taken; namely, from the most intelligent of the workmen themselves?—Yes.

2020. Can you point out any mode by which that system of inspection and promotion could be best promoted?—The only mode I can point out is, by schools for teaching mining theoretically; through schools, in addition to their own practical information.

2021. In the north of England, at this moment, are there schools generally established at collieries?—Yes, generally there are.

2022. Are there any principal collieries, in point of fact, without schools?—I think not.

2023. What do they teach generally at those schools?—Reading, writing and arithmetic.

2024. Anything more?—Not much more, generally; there are some which teach mensuration, and the higher branches of mathematics.

2025. Are there any other subjects which you think it would be desirable to teach in those schools; I mean in educating men fit to manage collieries?—I think part of the education should consist in making them understand how to manage collieries, the nature of the gases and airways, and plans of colliery workings, and all such things, that appertain to the safe management of a pit.

2026. It would not be a very difficult thing to ingraft that extra teaching on the schools which are now established?—They would perhaps be too small for that purpose.

2027. Do you see any difficulty, in reference to the teachers themselves?—Many of the teachers, or all of them, have not been practical miners, nor do they understand mining at all generally.

2028. Then you think it would require an entirely new teacher from those who are now employed?—Yes.

2029. How are those schools now supported?—By the miners themselves.

2030. Are

2030. Are they, in your opinion, sufficient for the objects sought; namely, the education they profess to give?—Not by a great deal.

2031. You think there is a deficiency in the means of education among the mining classes?—A great deficiency.

2032. And you would wish it to be extended to practical mining operations?—Yes.

2033. *Chairman.*] Looking at the last five or six years, is it your opinion that the children of miners are improved in their education or not?—I think they have, on the whole.

2034. At each colliery in Northumberland and Durham is there a school?—I believe at every one, or nearly so; I cannot say for one particular exception or two.

2035. When you say that the men support the schools themselves, do you mean that they pay so much in the pound from their earnings, or that they pay so much a week to the master of the school themselves?—No; they pay to the master themselves.

2036. By voluntary contributions?—So much per child.

2037. Do you think the miners would agree to a rate, to paying so much in the pound, which should be stopped from their earnings, for the purpose of education?—They would, if they had some power attached, to see if it was rightly distributed.

2038. Provided they had a committee appointed to see that the master was a proper and efficient man, you conceive they would have no objection to schools being established on that principle?—I think not.

2039. And to teach mining?—To teach mining.

2040. If it was an increased expense to teach the children practical mining, you do not think they would object to pay a little more increased cost for that purpose?—I believe they would not.

2041. When you say practical mining, let the Committee understand what you mean; by teaching them practical mining, do you mean the science of mining?—Yes.

2042. You do not mean the practice of mining, but the science of mining?—Yes.

2043. Therefore a master could be found, who was not a working man, who would be efficiently competent to teach them the principles of mining and ventilation, and everything connected with the science of mining; is that so?—Yes.

2044. What rate could such a master be obtained at?—I think he should have eighty or one hundred pounds a year.

2045. Would you recommend it to be embodied in the Act of Parliament, that it should be compulsory on each colliery to have a school, and that those schools should be paid for in the manner they have now designated?—I think it would take very well with the colliers.

2046. Do you think there would be no objection to allowing a certain percentage of their earnings to be stopped from them, for the purpose of education?—They would be quite willing, under the circumstances I have described.

2047. Those circumstances being, that they should have some control in the management themselves?—Yes.

2048. Mr. *Locke.*] Would it be a desirable thing, that at each of those colleries there should be a map of the colliery placed in the school room?—No; but a general map, showing the principles of ventilation, might be adopted.

2049. A general map would be better than a map of the particular colliery?—Yes.

2050. Are maps essential in carrying on a colliery?—Quite so.

2051. Do you see any objection in its being placed in the school-room for examination?—I could only conceive that the owners would object to it.

2052. The workmen would not?—No.

2053. Mr. *Stephenson.*] At the schools which you now have amongst the collieries in the north of England, you say they generally teach reading, writing and arithmetic?—Yes.

2054. At what age do the boys generally leave the schools?—About nine or ten at present.

2055. Do you think that if the master was a scientific miner, that he could convey to a boy's mind at eight or nine years of age any important information

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respecting mining?—I think a good impression would be made at that time on their minds before they went to work.

2056. Do you think that would be a better preparation at that school, than having a school of mining at which they could attend whilst they were working under ground, and gaining practical information?—I think it would be necessary to continue it by night schools.

2057. Would you not rather leave the schools as they are now for the boys, to add to the present system a mining school, which might be accessible either by night or by day, for those who are workmen in the mines?—I think the other might be employed to induce a notion on the part of the boys to go to these night schools, for without that they would not have that notion.

2058. *Chairman.*] How many hours do the boys work now in the pit?—Twelve hours.

2059. Do you think that is too much?—Rather too much.

2060. Can you state the earliest age a boy ought to go to a pit at all?—Not before 14.

2061. How long do you think he ought to work at the pit, provided he goes at 14 years of age?—About eight hours.

2062. Is your evidence now with reference to his physical powers, or with reference to the means he should have, after he leaves employment, of educating himself by these night schools?—I think both of them are enjoined.

2063. Is it your opinion that a law should be enacted prohibiting boys of certain ages working more than a certain number of hours?—Yes, I should like that law very much.

2064. Just explain to the Committee what you think would be the right law?—I think that there should be two shifts of boys instead of one. They are 12 hours at work, and, before they get home and get washed, two more are consumed, which necessarily keeps them 14 hours from home. If there were two shifts of boys employed, they might work six or eight hours each, from 10 years of age to 14, for the law at present is that they must be 10 before they can go down to the pit.

2065. Do you not think that a law of that kind would have the effect of diminishing their wages; do you think the coal proprietor would be willing to pay the same sum for working eight hours as for 12 hours?—No.

2066. Do you think it beneficial to the boy that his wages should be diminished, and that he should only be allowed to work a certain number of hours?—Yes, in order that, after he had done his work, he should have his energies and faculties in full force to imbibe any education that might be offered to him.

2067. Mr. *Child.*] Would the parents be satisfied that their children should only be allowed to work a short period and have their wages diminished?—Many would not, but the great body would be satisfied with it.

2068. Mr. *H. Vivian.*] Assuming that an efficient school was attached to each colliery, do you think that any regulation could be made that boys should not be employed who had not attended that school, in order to produce a strong moral effect as to the necessity of educating the children?—Yes; it would have a great effect in keeping them at school.

2069. Mr. *Locke.*] In point of fact, you would require, in that case, a certificate that he had been at school before he was permitted to go to the mine at all?—Yes.

2070. Did I understand your opinion as to the employment of boys to be, that you would by law enact that between the ages of 10 and 14 no boy employed at the colliery should be permitted to work more than eight hours a day?—Just so.

2071. After 14, you would not have any restriction; you would leave that as a matter of arrangement between the boys, the parents, and the owners?—Yes.

2072. Your restriction would be limited from 10 to 14?—Yes.

2073. Up to 10, you would not allow any boy to be employed at all?—No.

2074. Up to 14, your own opinion is, that they should not be allowed to go into the pit?—As the present law is 10, they should work half shifts, from 10 to 14, and thus insure a better education among them.

2075. Mr. *H. Vivian.*] The purport of your evidence has rather been, that neglect

neglect occurs on the part of the owners of collieries?—Or their managers, chiefly.

2076. Are you aware of the expense which an explosion puts the colliery owner to?—I am aware it is very great.

2077. What should you conceive the expense of such an explosion as the Killingworth or Hepburn?—Three or four hundred pounds.

2078. Does it not happen that when an explosion takes place, the stoppings, main doors, brattices, and frequently the guides in the pits, are all shattered and broken to atoms?—Yes.

2079. Do you conceive they could be replaced for two or three hundred pounds?—In those collieries you speak of that was not the case. It was only in one district of the pit, and that a very limited one, where an explosion took place, and a few doors and brattices were broken; and thus little expense incurred.

2080. As a general rule, we may assume that an explosion is an exceedingly expensive thing to the proprietor of the pit?—Yes.

2081. It is also very true, is it not, that great distrust arises in the minds of workmen, and the effective working of the colliery is stopped for some time after the explosion?—Very frequently so.

2082. So that great loss arises from the non-production of coal?—Yes.

2083. Therefore is it not vastly to the interest of the proprietor of the mine that the mine should be kept in an efficiently ventilated state?—Yes, it is entirely to his advantage.

2084. Then to what do you attribute the neglected state of the mines in the north of England?—I think it is from false economy.

2085. Mr. *Child.*] Would not workmen be disposed to work for less wages in mines which are notoriously well ventilated, than in mines that are the contrary?—Yes.

2086. Mr. *H. Vivian.*] Do you conceive it possible to put a fiery pit in such a condition that it should be absolutely safe?—Yes.

2087. As regards wilful neglect on the part of men, do you conceive that it would be desirable that specific enactments should be made against wilful neglect on the part of men?—Yes.

2088. Have you ever known cases in which men have been guilty of smoking in fiery mines?—Not where it was prohibited.

2089. You have never known a case, where smoking was prohibited, where smoking took place in the pit?—Never.

2090. Have you ever known a case of a man unscrewing his lamp?—Not where it was prohibited.

2091. Do you think it would be very desirable that specific enactments should be made against wilful neglect on the part of the men?—Quite so.

2092. *Chairman.*] In your opinion, it is as highly important to guard the mine from accidents arising from the carelessness of the workmen, as it is from inefficient ventilation, and want of attention on the part of the viewers?—Most certainly.

2093. Mr. *Stephenson.*] You just now, in reply to a question, stated that you thought that all fiery pits might be easily made safe by careful ventilation?—Yes.

2094. Is it not a prevailing opinion among the best informed miners as well as viewers in the north of England, that sometimes a discharge of gas is very large and sudden?—Yes, there have been such cases reported, and undoubtedly they were so.

2095. In those cases, ventilation might prove inefficient for a time?—Yes; if the ventilation was weak, and only sufficient to keep the mine at a safe point, then any extra amount of gas coming out would ensure an explosion, or make the pit dangerous.

2096. You have heard of some instances, in the north of England, where it is supposed that a large quantity of gas was emitted by the coal in a moment?—Yes.

2097. Then a fiery pit, although it might have abundant ventilation just previous to that, might become dangerous under those circumstances?—Quite so.

2098. Therefore, your answer must be received with some little limitation, that is, that by careful ventilation you could not prevent accidents altogether?—I would like my answer to convey this, that in an ordinary discharge of gas, a mine could

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could be rendered safe. These extra outrushes of gas might render us still liable to a loss of life which we could not avoid.

2099. Mr. *H. Vivian.*] It is not always possible to explain how an explosion has taken place?—Frequently very difficult indeed.

2100. In the case of Hepburn, that is conceived to be a well ventilated pit?—Yes.

2101. The cause of the explosion was supposed to have arisen from the gas lodging in certain undulations of the roof?—Not the last explosion, the previous one.

2102. So the current of air swept along, and allowed the gas to remain in those undulations in the roof?—Yes.

2103. Could any human foresight have prevented such an occurrence?—Yes; if the gas was known to have been there, it could have been removed.

2104. But it was not known to have been there?—Then a proper inspection would have proved it to have been there.

2105. Then an inspector would have been required to test the fact, whether gas existed in each particular undulation of the roof of a large colliery?—Yes.

2106. Would that be practicable?—Quite so.

2107. With eight inspectors for the Northumberland and Durham districts?—Yes.

2108. To prove the fact of the existence of the gas in the undulations of the roof of a large colliery?—Yes.

2109. What is the area of a large colliery, such as Hepburn Colliery, in square miles?—I am sure I cannot speak to that.

2110. *Chairman.*] When an inspector goes to a pit, do you think that the viewer would not take him, if he could, to the best parts of the pit, and avoid the worst?—That is generally complained of.

2111. If the inspector knew his business, he would be pretty well up to that?—Yes.

2112. If he saw a disposition on the part of the viewer to avoid any part of the pit, he should naturally go there first?—Yes.

2113. And ask to see if there was anything the matter there?—Yes.

2114. With respect to these eight sub-inspectors you have spoken of, you would not like the inspectors' visits to be so frequent as to remove the responsibility from the coalowner in anyway, or from the viewer?—Not in the least to remove the responsibility from the viewers.

2115. Nor would you like to interfere with the coalowner in any way, as to carrying on the works in the way he thought best for his own economy and profit, provided he did so with a due regard to the safety of the lives of the people?—I would not interfere at all with the mode of working.

2116. In point of fact, in your opinion, as little interference should be made with the proprietors of collieries as possible?—Just so.

2117. Bearing in mind that due regard should be paid to the safety of the lives of the workmen?—That is all.

2118. I see, by the returns of accidents, that a great many of the accidents occur from the falls of the roof; in your opinion, is there generally in the mines of the north of England sufficient pit-props supplied at all times to the workmen?—There is, generally so.

2119. Do you think that anything could be done to avoid this loss of life from the falling of the roof?—Yes.

2120. What?—There should be more hands employed as deputies.

2121. Is it the deputies' particular duty to see that sufficient pit-props are placed, that the roof should be made as safe as possible?—Yes.

2122. Who applies the props?—He does.

2123. In the north of England, is it not the custom for the miner to place his own props?—He is not expected to do so, but from the want of sufficient hands or deputies he frequently has to do so.

2124. Generally, in the mines in the north of England, are there not sufficient hands kept to put up the props, so as to make the mines as secure as possible?—Not generally.

2125. If more of these deputies were employed, less loss of life would occur from the falling of the roof?—I feel confident of that.

2126. However careful the deputy might be, or the number of men employed,

ployed, it would be impossible to avoid accidents at all times from the fall of the roof?—Yes. I think there are some cases where it would not be possible to avoid it; some roofs are very slippery and very deceitful, and require more care; the falls are unavoidable in some instances.

2127. In some districts it is the custom in collieries to pay the hewer so much for standing his own timber; do you think that would be a better plan than to employ deputies?—No, I think not.

2128. Would not the collier, from a due regard to his own life, put as many props as he could to make the roof safe?—I think he should do so.

2129. Then bearing in mind that he was the man who would suffer if the roof was to fall, is it or not your opinion that it would be a better system if, instead of employing deputies to put props, that each man should in his own void stand his own timber, and be allowed so much for each timber he stands?—I think it would not be so sound and safe a way as the present mode.

2130. Then you think that the collier would not have a proper regard to his own life, and in his anxiety to earn more wages, would push on and hew coal, and he would not stand sufficient timber?—It is not owing to that cause that I think so; it is his want of practice in the knowledge of the roof and the nature of it. The deputy acquires a good knowledge of the kind of roof that is in his district, and he knows almost to a nicety how many props are wanted through the day there.

2131. At the same time you do not state that the collier is not in many cases reckless of his own life?—He is sometimes regardless of danger.

2132. You have known cases of colliers going into places where they were actually forbidden?—I have not indeed.

2133. You do not know of any other means of preventing the fall of the roof except proper support and timber; those are the only means you can suggest to remedy these accidents?—Yes, and the employment of good deputies.

2134. With all the attention which you have paid, you do consider that accidents of that kind can be altogether avoided?—No, they cannot be entirely avoided.

2135. With regard to winding the men up the shafts, nearly one-third of the accidents all over England occur from accidents at shafts; in the north of England, when the pit is done with, is it walled round or left open?—Walled round.

2136. In all cases?—Yes.

2137. Is that the custom of the district?—Yes.

2138. Suppose a pit was left open and unwalled, would there be complaints?—I think it is likely.

2139. Who would be the parties to raise them?—Some of the overseers or constables of the parish.

2140. Is the use of cages common in the north of England?—Quite general, I think, now.

2141. And guides?—Yes.

2142. Do you think there has been less loss of life since the cages have come into use?—I think there has been.

2143. What cages are now in use?—Large iron cages, with guides on.

2144. Are they safety cages; are they Mr. Fourdrinier's, or upon that plan?—None have those of Mr. Fourdrinier's but one or two collieries.

2145. Where those patent cages are applied, have any accidents occurred there?—Not that I know of.

2146. Are you quite sure they are employed in any collieries in the north now?—I only know that they were employed at Monk Wearmouth and Unsworth.

2147. Have you ever seen them yourself?—I saw them at Unsworth.

2148. Have you sufficient experience to know whether they are beneficial or otherwise?—I think they are quite sufficient to save life when the rope breaks, or a chain.

2149. Have they not a tendency to make the manager of the pit more neglectful, and to keep his ropes and his machinery in worse order?—I think not.

2150. You are speaking of what exists now at this moment; there are pits working with these patent cages?—It is a few months since I saw it at Unsworth.

2151. When were you at Unsworth?—Eight or ten months ago.

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2152. Whose apparatus was at work there then?—Fourdrinier's.

2153. Mr. *H. Vivian.*] Have they not been abandoned at many other collieries?—Not that I know of.

2154. *Chairman.*] Since these cages, whether patent or otherwise, have been employed, you say a greater number of accidents have occurred than before?—Yes.

2155. Can you account for that?—I think it is owing to the great speed with which they wind the men up, and also obliging them to come to bank on the top of the full tubs, drawing coals and men up at the same time in the same cage.

2156. When the men go to their work in the morning, is the full coal coming up when they are let down?—Not at that time.

2157. They always have an empty carriage to themselves?—Yes.

2158. But on coming up they come up on a full cage?—Yes.

2159. Then their increased weight makes a greater strain on the machinery, and of course the rope has a greater tendency to break?—The more frequent of the accidents in the shaft happen, not from the rope breaking, but from the cage catching some of the joints of the guides, and breaking all up together.

2160. Are the ropes and the machinery in the north of England generally kept in good order?—Yes

2161. Sufficient attention is paid to that?—Yes, generally so.

2162. Would it not be possible then to avoid these catchings that you allude to, and to have the slides in such order that the cages never would be liable to catch in their ascent?—That proper attention should be paid to them, is necessary, and that they should wind the men at less speed, and without drawing coals at the same time.

2163. Would you enforce those regulations by Act of Parliament?—I think they should be attended to by Act of Parliament.

2164. Mr. *H. Vivian.*] When you say drawing coals at the same time, do you allude to drawing coals in the same cage with the men?—Yes.

2165. Have you any objection to the men descending while coals are being wound by the other rope?—Not if there be a partition between the ropes.

2166. *Chairman.*] If the speed were to be reduced, and anything was to happen in the pit to catch, as you have described, it would be easier for the engineer to stop the engine?—Yes.

2167. In your opinion, it is the great speed the engine is going at which prevents the facility of stopping the engine, and consequently the life of the workman is sure to be sacrificed?—Entirely.

2168. Mr. *Locke.*] What is the present speed at which they pull coals?—I cannot ascertain that.

2169. How many minutes to 120 fathoms?—Probably about three minutes.

2170. As much as that?—Yes.

2171. *Chairman.*] You do not know that they pull a great deal faster than that?—I never ascertained exactly; so I merely give that opinion from my present thoughts.

2172. You say they go a good deal too fast; have you formed any opinion in your own mind what speed would be a safe one?—No, I have not.

2173. You have already stated that you think if they went slower, the man at the engine would be able to stop his engine, and thus prevent the destruction of the guide rods?—Yes.

2174. Is it possible, at any reasonable speed, that the engine-man should know that something had caught, so as to be able to prevent the total destruction of the rods?—Yes, a man drawing at moderate speed; should a slight interruption take place, there is generally a signal rope down by the side of the guides, and the men would then have time to pull this before any destruction of life took place.

2175. You think the catching of a tub or guide on the rods is so slow in its operation that a man pulling at the rapper rope might then inform the engine-man at the top, and thus prevent the accident?—Yes, if the speed was moderate.

2176. Mr. *H. Vivian.*] Is it not customary now in the collieries in the north of England to give a signal when the men are coming up?—Yes.

2177. Do they not always wind at half speed?—They wind at a reduced speed; not so much as that, I think.

2178. Do you think it possible, as you have stated, for a man to put his arm out

out of a cage to pull a rapper rope?—Yes, the momentary suspension of the speed by the obstruction would enable a man of sufficient presence of mind to touch that wrapper rope, and if the cage was on that side of the shaft to give a sufficient pull.

2179. Mr. *Locke.*] Supposing the cage were on the other side of the shaft?—Then he would not have so ready an access to it.

2180. Can you not suggest some better remedy, than that a man should put his arm out of the cage and ring a bell to the engine-man, in order to tell him there was something wrong in the shaft?—I can only suggest that a more moderate speed would ensure fewer chances of the cage coming in contact with obstructions.

2181. You think if the speed was slower, there would be less chance of the obstructions having the effect of destroying the whole guide rods?—Yes.

2182. Would it not be better that you should regulate the speed, and inspect the guide rods and keep them in such perfect order, as that any little obstruction you should have to check should not cause the breaking up of the rods?—Yes.

2183. Mr. *Stephenson.*] How many accidents arising from the slides being out of order in the north of England have come within your knowledge?—Very few.

2184. Can you name any?—I could not particularise, at the present time; the complaints of the men to me are that they draw them at too great a speed, and thus endanger their lives; they say if anything was to happen, or should happen, we should be all killed. This letter I might read as a letter from a collier in Northumberland:—"March 7, 1853, Bedlington Colliery,—Dear friend, I write these lines to you for to let the Government inspector of the mines know that Bedlington Colliery is in a very bad state. At present there is two pits drawing coals; one is a upcast, and the other is a downcast pit, and the air from the downcast pit goes about 150 yards in, and returns to the furnace, and you will find my words true when you come to Bedlington Colliery; and when a man fires a shot the reek (powder smoke) stands there, no air to carry it away; and a man can hardly see the candle that he is working with, and it is very unhealthy for any man or beast; it should not be allowed; a man is half poisoned every day he goes to work, and the Government inspector must come as soon as he has an opportunity to come to Bedlington Colliery. And there is another thing that I must state to you, down in Bedlington Colliery; there is seven men had to come up the pit together with two full tubs below them, each tub holds seven hundredweight and a half, that is, 15 hundredweight of coals; and each tub weighs four hundredweight a piece, and the weight of the cage one ton and a half; one of the men that made the cage told me that; that is two ton 13 hundredweight without a man being in the cage; and average of seven men, 10 stone a piece, that will be eight hundredweight, six stone; three ton, one hundredweight, six stone. What a shame it is that a man has no more protection for his life."

2185. Mr. *Fitzroy.*] When did you receive that letter?—March 7, 1853.

2186. Did you forward that to the Government inspector?—I did.

2187. Did he visit that mine in consequence?—He did.

2188. Was any alteration made at his suggestion in either of the particulars, as to want of air, or as to the weight carried up the shaft?—In respect to the air, there was some difference made, an improvement.

2189. What improvement did he suggest, or what improvement has been made?—He suggested the alteration of some stoppings being put up, or doors hung to improve ventilation.

2190. Have you visited that mine since the inspector visited it?—No.

2191. Have you heard from any one of the workmen employed in that mine that there is an improvement in the ventilation?—I heard from one of the workmen that there was an improvement in the ventilation.

2192. Has there been any alteration in the weight taken up?—There was not then, when I had the other information.

2193. Are you aware whether there was any suggestion made by the Government inspector on the latter point?—Not on that point.

2194. In whose district is this coal mine?—Mr. Matthias Dunn's.

2195. How can you be aware whether or not the inspector suggested anything with respect to the weight taken up the shaft?—The inspector called on me, and told

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told me he had made some suggestion as to the mode of ventilation. I asked my informant, the next time I saw him, whether that was so or not. He said it was; but he said there was no alteration with respect to drawing the coals and the men.

2196. Are you aware, of your own knowledge, whether or not the inspector made any representation to the proprietor of the mine, as to the danger pointed out in that letter?—No.

2197. Are you aware how long a time had elapsed since the previous visit of the inspector to that mine?—I cannot tell.

2198. Are you aware whether that mine had ever been visited by the Government inspector?—No, I am not aware of it.

2199. *Chairman.*] You do not know whether it has or not?—No.

2200. Mr. *H. Vivian.*] Is Bedlington a fiery mine?—Not very.

2201. *Chairman.*] In your opinion, provided proper regulations were made, and the inspector had the power to see that the pits, machinery, and ropes were kept in good order, and that the slides which you have alluded to were always kept in sufficient order, do you think it would not almost entirely do away with the chance of accidents in winding up and down the people?—I think it would.

2202. In your opinion, would you wish that such regulations should be enforced by Act of Parliament, and that the inspector should have the power to see all the pits and the machinery, and everything connected with them, should be kept in proper order?—Yes.

2203. Mr. *Locke.*] Would that satisfy you if that were done, without any restriction as to the speed of pulling the coals?—Yes; I think the inspector's own opinion and judgment might be a sufficient guide to protect the men in that respect.

2204. You were asked about putting up props; is it the habit in the north of England that the miners should put up the props, or is it left to independent parties?—The practice is, that the independent parties have to put them up, but frequently the miners themselves put them up.

2205. That is, when the proper parties, those employed by the owner, fail to perform their duty, the miners, in their own defence, for their own security, are obliged to put up those props of wood?—Not from an inability to perform their duty, but having too many men to wait upon, the miners are obliged to do it or be idle.

2206. In your judgment the defect arises from the deficiency in the number of persons employed to put up the props?—Yes; I may say that I have, many a time, myself put up all the timber I have used in my place, for a week together, and I have seen many others do the same.

2207. Are the miners allowed anything for putting up these props?—Nothing whatever.

2208. The system in the north being, that the putting up the timber is entirely excluded from their labours?—Quite so.

2209. In your judgment, if the miners were permitted or ordered to put up their own timber, and had the management of the propping themselves, do you think that that would lessen the number of accidents arising from the roofs falling in, or increase them?—I am afraid it would not lessen them at all at the present time.

2210. Therefore, I may understand from you, that although there be this insufficiency in the number of men employed, you do not think, if the miner had the timbering in his own hands, the number of accidents would be diminished?—I think not.

2211. Can you tell the number of accidents that arise from the falling of roofs, in proportion to the number of accidents in the colliery?—I cannot say.

2212. Are they of very frequent occurrence?—Yes.

2213. *Chairman.*] You stated yesterday, that the workmen were not satisfied with the coroners' juries; have you ever heard them express any opinion how they would like to remedy the law, and make it satisfactory to themselves?—Their general opinion is, they wish a better class of juries.

2214. Is it possible to obtain a better class of juries from the places where the accidents occur?—Not in the localities.

2215. Have you ever heard the miners themselves express an opinion as to any alteration in the law that would be satisfactory to them?—There has not been any decided opinion expressed as to what should be substituted; but they complain

complain very much that the master blacksmith, or master joiner, and a colliery viewer from another place, are on the jury.

2216. Would it meet their views, provided it was enacted that no person engaged in the working of a colliery should be on the jury?—I think that is necessary.

2217. Would that meet the views of the colliers, and satisfy them as to the jury?—Yes.

2218. Do you think the practice and power of the coroner only being able to return a verdict of accidental death, or, in cases of gross misconduct, of manslaughter, is not an improper one?—Yes, I think so; he ought to have some intermediate power.

2219. Mr. *Cobbett.*] You say he ought to have some intermediate power?—Yes.

2220. What power?—Some power to assess damages or penalties.

2221. You would give the coroner power to assess damages?—Yes.

2222. Or to impose penalties?—Yes.

2223. *Chairman.*] Is there anything else you desire to state to the Committee?—I cannot say that there is.

2224. You came here to represent the association; it is by their desire that you are here giving evidence to-day?—Yes.

2225. Therefore of course they must be aware of the existence of this Committee?—Yes.

2226. You have nothing else to state to the Committee?—There was one other thing, with respect to schools; they are anxious that the Government should contribute 20 *l.* per annum for every 100 *l.* contributed by the coal hewers in the colliery.

2227. Out of the Consolidated Fund?—Out of some fund, and that the owner should allow all fines and forfeitures on the workmen's wages to go to such fund, for the purpose of establishing reading-rooms, libraries, and getting lectures upon any scientific subjects.

2228. Mr. *Fitzroy.*] Do the hewers propose to contribute anything themselves to these purposes?—That is in addition to the 2 *d.* per week, or 4 *d.* a fortnight, which they would contribute.

2229. Each man?—Yes.

2230. *Chairman.*] You mean 2 *d.* a week every man?—Yes.

2231. Mr. *H. Vivian.*] The fines and penalties levied in a mine are frequently now applied to a sick fund, where a sick fund exists?—Not frequently; only in a few isolated cases.

2232. Should you consider that it would be equally to the colliers' advantage to apply fines and penalties to a sick fund as to a school?—Equally so; though the latter is preferable.

2233. *Chairman.*] Is there anything else you desire to state?—Not particularly. I have this paper, containing an account of the experiments at Seaton Delaval. *Vide* Appendix

2234. What is this paper?—The experiments at Seaton Delaval, made on the 15th of June.

2235. Last year or this year?—This year.

2236. Who was with you?—Mr. Foster and Mr. Lamb.

2237. Those are the viewers of the pit?—Yes.

2238. Was anybody else with you?—The waste man, the overman, and others.

2239. Was there any Government inspector with you?—No.

2240. Did you measure the air by the anemometer, or by the powder smoke?—By the powder smoke.

2241. Have you ever seen the anemometer used?—Yes.

2242. You heard the evidence given with respect to the anemometer the other day; in your opinion do you think that the Government inspector could rely on the anemometer as a test for what quantity of air was passing through the mine, provided his visits were only once a month?—No.

2243. Do you not think that a badly-conducted overman could tamper with the anemometer, and render it not a sufficient test for the inspector to rely upon?—That is quite possible.

2244. Mr. *Locke.*] Did you take those measurements yourself, with Mr. Foster and the other person who was with you?—Yes.

2245. Did you agree in all your dimensions?—Yes.

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2246. Has Mr. Foster seen that paper, or any of the other persons with you?—The under viewer has.

2247. Do you know whether the conclusions or statements contained in that paper are admitted by the under viewer who has seen them?—Yes; I took each data down, and the powder was ignited and the smoke followed. I, with a watch, noted the time that was taken in passing the stated distance down, and the process of summing up the rate of current was done by the under viewer from these data.

2248. And from these data you have arrived at the quantity of air passing through the mine?—Yes.

2249. But whether it was properly distributed or not, is not on that paper?—No.

2250. It only accounts for the quantity of air passing down the down-cast or up the up-cast shaft?—Yes, and along the three chief passages into the workings.

2251. Does it contain anything else?—No.

2252. It is merely to show the extent of Seaton Delaval?—Yes.

2253. Mr. *Stephenson.*] Looking at this paper, which contains the statement of your experiments at Seaton Delaval, I observe a remark made here at the end of the calculations, giving an increase by the doors being opened of 9,345 cubic feet; now let me understand under what conditions the experiment was made in the first instance, before the doors were opened?—That door referred to is the door that leads to the boiler fires, and the boiler fires are fed by a scale at that door; one part of the experiments was made with that scale only and the door shut, and the other part of the experiment was taken with the door opened, and to show the increase.

2254. Mr. *Locke.*] Showing the increase of the furnace power?—Of the current.

2255. Mr. *Stephenson.*] This door was opened, and gave a free communication between the intake air and the engine furnace?—Yes.

2256. Where did you measure the velocity of the air by the powder smoke; what part of the mine?—In three distinct parts.

2257. At a considerable distance from the shaft?—Yes.

2258. Mr. *Locke.*] Where was the other part?—They were a good distance; in particular, the engine plane was a great distance from the shaft.

2259. What conclusion do you draw from this statement that you make here, giving the increase, with the door being opened, of 9,345 cubic feet?—I have no conclusion to come to from that; it was the result of a thought that simply struck Mr. Lamb the under viewer at the time, that there might be an increase by opening the door.

2260. You only increased the ventilation in this way by taking so much more air from the intake, and thus rendering the other parts of the mine less effectually ventilated?—It was done to prove whether that was the case or not.

2261. What was the object of the experiment?—It was to prove whether it would lessen the air current into the workings or not.

2262. If that was the object of the experiment, it was not necessary for you to take the increase of air 9,345 cubic feet at that door; ought you not to have taken the speed of the air by powder smoke, at the interior of the workings, away from the shaft?—They were taken at a great distance from the door, at the three separate places stated in the paper, and showed the increased amount of air going into the workings by the door being open.

2263. Therefore there was this increase through the working, notwithstanding that so much air had been abstracted from the intake by the opening of the door?—Yes.

2264. *Chairman.*] Did you make any experiment with the steam-jet alone without any boiler fires, merely by the motive power of the steam?—Just as it was.

2265. Then there was the furnace and the other heat going up the chimney, to rarefy the air, as well as the steam-jet?—Yes, the heat of the boiler fires, not the furnace.

2266. Mr. *Stephenson.*] When you opened the door to allow more air to be taken from the intake, although you robbed the intake of so much air, the furnace then burnt more vigorously, and heated the up-cast shaft to a higher temperature, and therefore although you borrowed some air from the intake to increase the intensity of the furnace, that increased intensity was more effective upon

upon the distant workings?—Yes, it caused a greater amount to go through all the workings. Mr *M. Jude.*

2267. Mr. *Locke.*] As I understand, you fancied you gained greater power of ventilation by that means to the extent of 9,000 square feet?—Yes. 30 June 1853.

2268. And under a proper system of distribution, do you think it might be made use of as an increased means of ventilating the colliery?—Quite so.

2269. You had both the furnace and jet employed in that colliery?—No furnaces, only boiler fires, gas retorts, and the jets.

Mr. *Robert Henderson*, called in; and Examined.

2270. *Chairman.*] WHAT are you?—I work as a practical miner at Monkwearmouth Colliery, and carry on business as a brass-finisher. Mr. *R. Henderson.*

2271. How long have you been employed as a practical miner?—Twenty-eight years.

2272. Constantly hewing coal in the pits?—I have been out of the pits about three years of the time at intervals, working various works.

2273. Are you a hewer of coal?—No, I work at stone-work, by contract for it.

2274. Mr. *H. Vivian.*] Chiefly in driving stone-drifts?—Yes, and other work.

2275. *Chairman.*] Were you selected as part of a deputation from Mr. Dunn's district to come here and give evidence?—Yes.

2276. When did you receive information?—About three days before I came here.

2277. Did you ever work in any other colliery than Monkwearmouth?—Yes.

2278. State where?—I commenced my first operations at Kenton, I removed from there to Cramlington, then to Seghill, from there to Tyne-Main, then to Fawdon, and from there to Felling, and then to Killingworth.

2279. In point of fact, you have worked at a great many mines, and have a pretty extensive practical experience?—Yes.

2280. You said you were a worker in brass?—I carry on the business of a brass-finisher at the same time.

2281. You have invented a safety lamp?—Yes.

2282. Has that been in use at all?—It has.

2283. Have you got one here?—Yes.

2284. Hand it in?—Yes (*the Witness handed the lamp to the Committee*).

2285. The safety-lamp on the table is the one that you have invented?—Yes.

2286. And it differs from the Clanny lamp, inasmuch as it has a double glass, and the space between the two glasses is filled up with distilled water?—Yes.

2287. What is the object of having it so constructed?—My object was to remove the objections of the colliery viewers in 1849 to the Clanny lamp, although they are not grounded on sound principles with regard to the cracking of the lamp.

2288. Is it not something similar to the lamp invented by Dr. Glover?—It was previous to Dr. Glover's; the only difference is, that Dr. Glover's takes air down between the two cylinders, and separates them.

2289. And yours is one cylinder?—Yes, united top and bottom.

2290. With merely holes to let the water in?—Yes.

2291. What is the weight of that lamp?—Three pounds and a half.

2292. Has that been used extensively in coal mines?—That lamp has been used 10 months in Monkwearmouth colliery by young Laing.

2293. What kind of light does it give?—A good light.

2294. Better than the Davy?—Considerably.

2295. Mr. *H. Vivian.*] What is the object of the water between the glasses?—To equalize the temperature of the glasses.

2296. Do glasses frequently crack from heat?—No, they do not frequently crack.

2297. *Chairman.*] Have you ever known one of your lamps crack?—I have not known any lamp crack.

2298. Constructed on your principle?—I have not.

2299. Not any lamp?—Not by fair burning.

2300. Mr. *Locke.*] Does it generate any steam above the surface of the water?—It does not.

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2301. Have you seen that yourself?—The first glass that I had made cost me 9*s.*; I connected it with brass fittings and continued to burn the lamp between two hot walls for one week, but no steam appeared whatever; I then took at intervals a pint of cold water and threw it on the glass to try to break it, but did not; I then reduced the glass to the present size.

2302. Have you ever known any of them broken by heat?—No.

2303. Broken by any other means?—Yes.

2304. By what means?—By a fall of the lamp.

2305. And you can answer for its giving a superior light to the Davy?—I can.

2306. Does it give a superior light to the Clanny lamp?—There is not much difference; the opinion of some is that it is much superior, and the opinion of others is that it is not.

2307. In your opinion, it is a safer lamp, the light being equal, because it prevents that cracking of the glass, arising from its getting heated if water comes in contact with it?—I do not think it is much superior to any glass lamp; I have implicit confidence in the Clanny lamp.

2308. *Chairman.*] And have you implicit confidence in Dr. Glover's lamp?—I have most confidence in all lamps that have glass round the flame, inasmuch as I have seen them extensively used at Monkwearmouth Colliery.

2309. Then you do not agree with the Report of the Committee of 1852, which says that no lamps are safe?—I do not.

2310. Your opinion is, that they are safe, and ought to be enforced in fiery collieries?—My opinion is, that all lamps constructed on the principle of Dr. Clanny's are perfectly safe.

2311. In those you include the lamps invented by Dr. Fife and Dr. Glover and yourself, and all lamps which have glasses to protect the lamp from the rushes or blowers of gas blowing through them?—I have not made any experiments with Dr. Glover's lamp or with Dr. Fife's. I have my doubts with respect to the principle of Dr. Glover's. I had the same idea, and made experiments, but on account of the difficulty of uniting the gauze properly at top and below, I entertained a doubt with respect to its being sufficient to prevent the passage of flame, seeing that the flame will pass with a very little injury to the gauze; I therefore gave up the idea, and adopted the present one.

2312. Suppose in Dr. Glover's lamp the gauze was properly united, your objection would be removed (*handing Dr. Glover's lamp to the Witness*)?—Decidedly so.

2313. And Dr. Glover's lamp is very considerably lighter and more portable than yours?—It is lighter, but my lamp can be made lighter; I make the lamps of this strength because they are more approved of by the workmen generally.

2314. The Committee take your answer to be, that these glass lamps being properly constructed are, in your opinion, perfectly safe?—Yes.

2315. Therefore, you think that in all cases where fire exists in any quantity in mines, that the Legislature ought to enforce the use of properly constructed safety lamps?—Yes.

2316. You do not say that with reference to having the ventilation worse, but as an adjunct to good ventilation?—Yes.

2317. Mr. *Locke.*] What was the temperature of the two walls when you burnt your lamps?—I had no instrument to take the temperature; but judging from the state of the place in which it was confined, it was not much below that at the Monkwearmouth Colliery, which I consider a good test for any lamp whatever.

2318. Is that about 78 or 80 degrees?—I have been informed, in some parts where I have made inquiries by the overmen, that it was as high as 86. It is so hot, that the perspiration from you runs down from your body into your shoes in some parts, although it is not generally so.

2319. *Chairman.*] You do not come here to represent your lamp as better than others, your evidence merely is, that all lamps made with glass, in your opinion, are perfectly safe?—Yes.

2320. Supposing them to be properly and carefully constructed?—Yes, and under the care of proper men.

2321. You stated, that in all fiery mines, you think the Government should have the power imperatively to enforce the use of the safety lamp?—Yes.

2322. Supposing

2322. Supposing the use of the safety-lamp was so enforced, do you think it ought to be secured by a lock and key at all times?—Yes.

2323. Should the workman have any key to open that lock?—No.

2324. You think then, that the key should be in the hands of proper persons so employed to take care of the safety-lamps down the pit?—They are in the north of England; it is a rule for the deputy in that district, that his work lies to examine all the lamps at a certain station, and to lock all these lamps properly; it is also expected that the workman is satisfied that that lamp is locked, and no man whatever is allowed either to take keys or any other instruments to open the lamp; if it is known, he is subjected to a penalty.

2325. Do you think that that law should be rigidly enforced in all cases?—The rules are sufficient, in my opinion, to enforce such regulations.

2326. Do you think, with respect to cleaning the lamps and repairing them, that one man should be employed at the top of the pit, whose constant duty it should be to fill the lamps with oil and clean them, and see if they are in repair, and if they are out of repair, to repair them?—A proper person should be appointed for that generally.

2327. And that no other person but that person so appointed should be allowed to clean the lamps, or fill them with oil, or repair them if necessary?—It would almost be impracticable in any extensive colliery in the north of England so to do.

2328. Supposing one man would not be sufficient, then you would have two, or a sufficient number, whose constant duty it should be, at the top of the pit, to fill the lamps and clean them?—I have no objection whatever to the workmen taking their own tops home, and cleaning their own gauze; but in my opinion, it is very desirable that there should be more pains taken in instructing the men generally on the merits of those lamps; I have known a lamp pass all the officers in charge, and be in a very dangerous state.

2329. If the man who had the care of the lamps, and who had to repair them, had them through his hand every day, do you not think that he would be the better judge whether the gauze was in repair or out of repair?—He could not do it, on account of the number he would have through his hand.

2330. Suppose there were a sufficient number of men, whose constant duty it was to repair these lamps, from habit of observation, would they not be better able to see whether any part of the gauze was out of repair than the common working man?—If he was sufficiently awake to the merits of the lamp he might; but in no such case should I say that a lamp should go into a pit without being examined by the deputy of that district.

2331. Mr. *H. Vivian.*] Supposing a man took his lamp-top home with him to clean, it would be necessary that that lamp-top should pass through the hands of a competent man before the man could take his lamp down the pit?—Yes.

2332. *Chairman.*] Do you think that the working men in your district agree with the Report of 1852, as regards the safety-lamp, or do you think they place confidence in the safety-lamp?—There is much difference in the opinions of the men on the use of the safety-lamp; I can only speak from what I have experienced, and what instructions I have from other parties. The men at Monkwearmouth will not work with a common Davy lamp if they can get a glass lamp; they generally buy a Clanny lamp themselves when the company has none in store. I have sold upwards of two dozen to workmen, which cost 11 *s.* each.

2333. In your opinion, has the ventilation improved within the last few years at the collieries in your district?—I could not speak generally to that; the colliery that I am in is a very difficult colliery to judge of; it has such extensive bounds, that no man can form any idea of what is going on in another part of it; but I am fully convinced that it is quite possible to carry a sufficient amount of ventilation through any mine, provided there is sufficient attention paid to the return airways.

2334. You have had no expereience of the steam-jet?—No; none whatever.

2335. You are in constant communication with the men in your own mine at Monkwearmouth?—No, not constantly in communication.

2336. Do you know their opinion as to the way in which the ventilation is carried on in the pit where you work?—The opinions are various; they work on two systems, the long wall and the bord and wall system.

2337. How do they ventilate at Monkwearmouth?—By furnace.

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2338. Mr. *H. Vivian.*] Is there a furnace at Monkwearmouth?—Yes.

2339. How long has it been erected?—I should think ever since it has been a colliery.

2340. *Chairman.*] Monkwearmouth is the deepest pit in the kingdom?—The part I am working in is 307 fathoms to the bed.

2341. Mr. *H. Vivian.*] Is that down the stone drift?—In the A pit.

2342. *Chairman.*] Is it your opinion, that when a sufficient ventilation is brought into a pit, by furnace or otherwise, great attention should be paid to carrying it all over the works by splitting the air?—Yes.

2343. Yes; and that the airways should be sufficiently large?—I cannot see how any mine whatever can be ventilated unless there is a sufficient amount of passage for the air to travel; I know, for a fact, in more places than one that I have seen, both in England and Scotland, that it is not possible for a man of my size, which is only a moderate one, to squeeze himself through the return main channels in parts.

2344. In the returns of the loss of life, it appears a great many lives are lost by the falling of the roofs; in your opinion is sufficient timber furnished to a colliery?—In some cases there is an abundance of timber, and in others there is a deficiency.

2345. Are there, generally, sufficient deputies to stand the timber?—The deputies, generally speaking, have more work than they can perform; at least I had when I was a deputy.

2346. You have been a deputy yourself?—Yes.

2347. Do you think it would be a better plan to entrust to a collier the standing of his own timber, rather than leaving it to the deputy?—I think not; the deputy is the most suitable person.

2348. Why not?—Because it is the duty of the deputy to examine and take the sense of the district he is occupied in; he is a man that has a very important office, inasmuch as he has to report to the overman the full state of his district with regard to gas, and that sort of thing.

2349. You heard Mr. Jude's evidence with regard to the winding up and down the pits; do you generally concur in what he has said?—I differ from Mr. Jude in some things.

2350. State in what respect?—I differ from Mr. Jude with respect to the man putting his hand out and pulling the bell-rope; I think it is quite impracticable.

2351. Do you agree that the inspector, by legislation, should be given a power to enforce the machinery and the ropes being kept in good order, and that the guides should be kept in good order also?—I am of opinion that the inspectors ought to have power to see that everything about a pit is kept in proper order, for the safety of the workmen generally.

2352. In your opinion, if that was more sufficiently attended to, do you think that the accidents would be a great deal diminished?—I think so.

2353. Have you to complain of the guides being out of order in the pit in which you are at work?—Not generally.

2354. Do you think the men are wound up the pit too fast?—I do.

2355. Do you think, that if sufficient attention was paid to the machinery, the guides being in perfect order, that any danger would arise from winding men up at the speed at which they are wound up now?—I think it would not be safe to wind them up at that speed, inasmuch as the engine-man would not have the same control over the engine that he would have if going at a slower speed.

2356. Mr. *H. Vivian.*] The winding-engine has a heavy fly-wheel attached to it?—Yes, generally.

2357. *Chairman.*] Then, in addition to giving the inspector the power to see that the machinery and ropes and guides were in good order, you would also give him a power by law to regulate the speed, so that the men should not be wound up faster than they thought consistent with safety?—It is desirable.

2358. Mr. *Stephenson.*] Do you know how many accidents of that kind have occurred in the neighbourhood where you work?—I do not.

2359. Are they not very rare?—I cannot speak to the fact.

2360. Do you know of any accident that has happened from great speed in your neighbourhood?—I cannot speak to the fact generally.

2361. Mr. *H. Vivian.*] Is Fourdrinier's cage now employed at Monkwearmouth?—They have taken the wedges off lately.

2362. Then, practically speaking, the cage is not now employed at Monkwearmouth?—The wedge is not used at present; at least it was not when I was there.

2363. And the wedge is the safety portion of the cage?—That is Fourdrinier's invention; but I am informed from good authority that the owner pays Mr. Fourdrinier still for the use of that, if they think proper to apply it.

2364. They have abandoned the use of it, as far as I understand at present?—It is not used at present.

2365. Are you aware why they have discontinued the use of it?—The reason why, as far as my information goes, is, that there was some difficulty connected with the wedge being entangled with the sides of the pit.

2366. So that the danger in using such a machine is, in truth, greater than that of using an ordinary cage?—Not if everything is in accordance with it.

2367. Is not the danger greater, inasmuch as the machine is liable to get out of order and get jammed in the pit?—The objection, I think, that is generally raised against the use of either Fourdrinier's or Bell & Grant's, is, that the small chain which adjusts the eccentric or the spring, is apt to break and cause the wedge to come into action, or the eccentric to come into action; and for this reason there are some objections to them.

2368. The result of that would be, that the cage would stop in the shaft?—It would if the chain was to give way.

2369. And the result of this stopping in the shaft would be, that the rope would coil on it?—It would rest down upon it, but the engine-man could not but know that such a thing had taken place.

2370. Still, with an engine going at that speed he could not instantly arrest his engine?—He could not.

2371. And the result would be, that the cage would give way and surge?—I cannot say that the cage would give way, because I have seen it hang.

2372. Have you ever seen Bell & Grant's?—It is the one I am speaking of; they use them at Monkwearmouth also.

2373. It has been found that the complication of the machinery is so great, that the use of them has been attended with more danger than the use of the ordinary cage?—I cannot say that; I have not sufficient experience to say that.

2374. They are not at present used?—Not when I left.

2375. The system of long-wall work has lately been introduced into Monkwearmouth colliery?—About three years in practice.

2376. Have explosions been more or less frequent since the introduction of the long-wall system?—There have been many partial fires, but with regard to being more extensive or less, I cannot say. But where the long wall is kept in proper order the ventilation is much better. The men work with a great deal more freedom with regard to ventilation.

2377. Have any serious explosions taken place in Monkwearmouth by which lives have been lost?—There have been lives lost, but not to such an extent as in other parts.

2378. Have those accidents occurred under the long-wall system?—Some have, and some have not.

2379. In your judgment, is the liability to explosion greater under the long-wall system as applied at Monkwearmouth, or under the ordinary board and wall system?—I prefer the long wall.

2380. *Chairman.*] Why?—It is easier to ventilate.

2381. Mr. *H. Vivian.*] What is the thickness of the seam at Monkwearmouth?—It varies from three to five feet.

2382. And falls readily?—In some parts of the seam it does not.

2383. Where it does not fall, can the long-wall system be carried out?—Yes, where the seam does not exceed that thickness.

2384. In that case it would be necessary to bring in materials in order to stow?—There is always abundance to be had in Monkwearmouth Colliery from the various movements of the mine.

2385. *Chairman.*] You heard Mr. Jude's evidence with respect to inspectors; he said, that in his opinion an inspector should be appointed, and eight sub-inspectors would be sufficient for that district; do you coincide in that?—I am of

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of opinion that sub-inspectors would be a great improvement, or would be the cause of much improvement in the ventilation of mines, inasmuch as the coal proprietors and viewers generally would pay more attention to keeping open the airways; it is very defective now.

2386. What class of men would you recommend as sub-inspectors?—Practical miners; a man that has been brought up to it, and could turn his attention to it, and not be easily deceived, who would search into every hole and corner. I would also impose on him the duty of travelling the whole area of the mine in his visits, which I think it is not reasonable to request the head inspector to do.

2387. But you would give him no power, you would give him solely the authority to report to the head inspector?—To report to the head inspector, and a proper ledger to be kept for reference.

2388. Do you think that the owners of collieries would have equal confidence in such a man as you describe the workmen would have?—I think so.

2389. Do you think that eight would be sufficient; how often would those eight be able to go through each colliery in their district?—It would be a very difficult question to determine the number; but eight would be an abundance.

2390. For the district you speak of?—Yes.

2391. And admitting there were eight appointed, how often would they be able to visit each colliery in their district?—I have not made a calculation.

2392. How often do you think they should visit?—I think their visits should not be longer than two months, and not less than one.

2393. You would appoint no inspection that should take the responsibility out of the hands of the coal proprietor or the head viewer?—By no means to interfere with the management of the colliery.

2394. You would not think it advisable to enact any law that would interfere materially with the operations of the coalowner or the viewer further than what was actually necessary for the preservation of the lives of the workmen?—No.

2395. Mr. *Stephenson.*] The present system in the north of England is, that a set of men called the waste men should travel the workings either wholly or in part every day?—The master wasteman is expected to travel, as far as my information goes, part of it daily.

2396. In the course of the week he has to go through the whole?—Yes.

2397. *Chairman.*] There are men always employed solely for the purpose of walking through the whole of the air courses of the colliery from week to week?—It is so at Monkwearmouth.

2398. For sub-inspectors, whose duty it would be to walk the waste, would you have that class of men from the present workmen?—They ought to be taken from the most intelligent and practical men, such as overmen.

2399. What would be the process, supposing a sub-inspector found the airways insufficient, to whom would you have him address himself?—He ought to inform the head inspector, and also at the same time the colliery viewer.

2400. The duty of the wasteman at present is, to inform the colliery viewer when the airways are not in good order?—He informs the overman or overviewer, and there it rests.

2401. That is your objection?—My objection to the present system is, that there is nothing to enforce, and the colliery overman and viewer lives in hopes for the better. There appears to be a slavish fear in the minds of overmen generally, with regard to the impression that is made upon his mind on the day when he takes in his bill, with regard to the expenses of the colliery not being reduced; and by this means, he passes things for the sake of a few shillings which would considerably improve the ventilation. Sub-inspection would remedy this, because those evils would have to be removed if Government enforced it.

2402. *Chairman.*] You said, that you thought the inspectors should not visit a mine less than once in two months, and not oftener than once a month?—I think that would be sufficient.

2403. Once a month, or once in two months, which would be sufficient?—He should be there once a month, but there are cases in which it is necessary that he might visit oftener than once in two months.

2404. Mr. *Stephenson.*] In fact, his visits ought to be regulated by the character of the colliery, whether it was dangerous or not?—Of course.

2405. There are many parts of the north of England coal-field, where the mines

mines are free from gas, and the roof is good, you would say there that monthly inspection is not so necessary as it is in the larger mines?—But notwithstanding that, these are places at which accidents have frequently occurred. Washington, for instance, is a seam which might be easily kept, but by placing implicit confidence there appears to have been some neglect, and an accident did occur.

2406. *Chairman.*] Are there any pits in Northumberland ventilated by natural ventilation, without any furnace at all?—Not that I am aware of.

2407. You heard what Mr. Jude said with regard to the coroners' juries; do you concur with Mr. Jude in his opinions as to the coroners' juries; do you think the present system of coroners' juries is satisfactory?—I think not.

2408. State in what respect you think it not satisfactory?—There appears to be no power whatever vested in the hands of the coroners' juries to inflict such penalties as are necessary for the relief of the distressed, and to enforce more regulations.

2409. When men are killed by accidents in coal mines, do not the owners come forward and do all they can for the support of the widows and children in your district?—Perhaps, as to the last explosion, that has been the case; such as Washington and Usworth, and some others, there has been a kind of circular or notice to the workmen generally, soliciting their aid, and they have given a shilling or sixpence, according to their circumstances.

2410. Do the proprietors of the mine contribute?—It is expected so.

2411. They generally do?—Yes, I think so.

2412. Mr. *Fitzroy.*] Do you think it would be an improvement if legislation should provide a forced contribution on the part of the proprietors of the mines in support of the wives and children of miners killed by accident, instead of leaving it to their voluntary contribution?—I think that there ought to be power in the hands of the coroner and jury to levy such fines as they thought the case deserved, in case of neglect; but I am of opinion that a fund ought to be established, to be supported by workmen, and the fines that are taken from the earnings, such as "laid out" and "set," and other forfeitures, should go to that fund.

2413. Do you think it desirable to make it compulsory on the proprietors of mines to provide for the maintenance of the wives and families of those who have been killed by accidents in their mines?—If there be power vested in the hands of the coroner and juries.

2414. No matter in whose hands it is vested, do you think it is desirable by law to make such a provision?—Yes, if caused by culpable neglect.

2415. Mr. *Cobbett.*] You heard Mr. Jude's evidence with regard to the juries who were summoned by the coroner; do you agree with him that persons who are connected with these mines, viewers and overlookers and so on, should not be summoned on the coroner's juries?—There is a fear of intimidation by summoning such as a master-blacksmith, master-joiner, and shopkeepers that have a sort of interest indirectly. My opinion is, that the juries ought to be made out with something like three or four, or five or six practical men, and the rest tradesmen generally.

2416. That is, there should be jurors taken not connected, directly or indirectly, with the coal mines?—No; I am of opinion that there should be practical men in all cases, either viewers or practical workmen, with a sufficient amount of knowledge to put such questions as are calculated to elicit the truth from the witnesses, with the aid of the inspector; by that mode I think the truth of many accidents might be come at, and more just decision come to.

2417. Mr. *Fitzroy.*] Have the verdicts given by coroner's juries in your district generally given dissatisfaction?—I am not prepared to say.

2418. Does not the answer you have just given assume, that the verdicts given by coroner's juries have not been consistent with the facts, and have given dissatisfaction?—The answer I have given intimates that the truth had not been fully elicited, and that there is a danger of tampering with evidence; I know of cases, at least I have been informed of cases, where men, when an accident has taken place, who have been witnesses, have been examined at the colliery office by the viewer, with reference to their opinion before they went there.

2419. How do you propose to remedy that evil; by altering the constitution of the jury?—If there be power vested in the hands of the coroner's jury to inflict fines as previously referred to, the men, such as sub-inspectors and

Mr. *R. Henderson.* practical men sitting on that jury, would be better calculated to put questions, and to find out the cause of these things.

30 June 1853. 2420. *Chairman.*] Do you think the workmen generally are satisfied with the coroner's juries at present?—The universal opinion, as far as I have gathered it, is, that one verdict is universally come to, that is accidental death; it is quite a common proverb.

2421. That may depend upon the state of the law, because, by the present state of the law, the jury has no discretion between accidental death and manslaughter; unless it was a case of very gross and wilful carelessness the jury would not be justified in giving a verdict for manslaughter; is that not so?—Of course they would not be justified.

2422. Then the jury have no power to give any other verdict than accidental death?—But the manner of summoning the juries is not, in my opinion, sufficient to elicit the truth in these cases.

2423. Mr. *Fitzroy.*] Do you think it would be an improvement if a certain number of practical miners were summoned on every coroner's inquest?—I think that it would have a tendency to elicit the truth, with the aid of the inspectors, more fully.

2424. *Chairman.*] You heard Mr. Jude's evidence with respect to schools; is it your opinion that the workmen would consent to the Legislature enforcing them to pay a certain sum out of their earnings in all cases for the support of schools?—They may in some cases differ, but I think, generally, they would coincide.

2425. With the same provision that Mr. Jude made, that is, that the workmen should have a certain share in the management of the schools, and in the appointment of the schoolmasters?—Yes.

2426. Do you concur in his opinion with respect to mechanics' institutions and reading-rooms that he spoke of?—I think that if there was an institution established, or some extension made in the colliery districts, in the way of establishing libraries, and a room of sufficient dimensions for lectures to be given on chemistry and the various branches of science, it would be calculated to do much good; but I should not depend on them for the education or the examination of officers.

2427. Mr. *Fitzroy.*] Is there a great want of schools amongst either the colliers or labourers in the district with which you are immediately connected?—I think all the colliers are provided with a school-room of some kind, more or less, large or small.

2428. Is the school accommodation generally sufficient to accommodate the number of children belonging to the different colliers?—I think not.

2429. Are most of the children of the colliers sent to school?—There is a great number sent, but there appears to be a defect with regard to the teachers; they do not appear to possess the same amount of attraction that there is in national schools, or in schools in large towns.

2430. In cases where parents abstain from sending their children to school, does it arise from a want of confidence in the schoolmaster or from want of means on the part of the parents?—Generally from want of means.

2431. What is the average rate of wages now paid to workers in coal-mines?—It is a very difficult question to answer.

2432. Mr. *H. Vivian.*] What does an efficient cutter or hewer get?—They vary very much, from 15*s.* to 25*s.* a week; it is very rare where they reach to 25*s.*

2433. How many days do they work to earn that money?—They will have to work 11 or 12 days a fortnight.

2434. *Chairman.*] They generally lose the Monday; they do not work much on the Monday?—Not in the district in any part of my experience.

2435. Mr. *H. Vivian.*] On what day are wages paid in the north of England?—On Friday generally.

2436. Mr. *Fitzroy.*] In the case of those colliers it is not from want of means that they fail to provide for the education of their children?—In some cases.

2437. In the case of men earning betwen 15*s.* and 25*s.* a week, it is not the want of means that prevents him from sending his child to school?—It is in some cases the want of means.

2438. What is the average charge made for schooling for children of that description in your neighbourhood?—The child at first going to school pays 3*d.*

3*d.* per week to learn plain reading, and as he advances, if he comes to write, 6*d.* a week, and when it comes that he can do arithmetic, he advances to about 7*d.* a week.

2439. Do you think that 3*d.* a week or 6*d.* a week would be too much for a man who was in the receipt of wages averaging from 15*s.* to 25*s.* a week to pay for his child?—I think it is more than he can afford generally.

2440. But you think that he would not object, notwithstanding the 3*d.* is more than he can afford, to pay the 7*d.* if facilities were given in other quarters to the formation of a school?—Not at all.

2441. Mr. *H. Vivian.*] Would you recommend the assessment being made on the child or the man, or on the earnings of the man?—I would recommend it on the man weekly, to be detained at the colliery office; but I apprehended that this would not raise sufficient funds for the education of the mining population generally.

2442. Mr. *Fitzroy.*] You contemplate then that all persons employed in labour in mines, whether married or single, should pay this weekly contribution?—Yes.

2443. Mr. *H. Vivian.*] And then have the benefit when they have children?—Yes; I may also add that at Killingworth colliery the owners built very extensive schools, and employed three teachers, a female teacher and a female for infant school teaching, and a master. The workmen there paid 6*d.* a fortnight, or 3*d.* a week, for a number of years, but after the colliery changed hands it was done away with, and they pay on the system I have just described of 3*d.* per week per child.

2444. *Chairman.*] Have you anything to say as to the establishment of a fund?—In my opinion, I think it is desirable that a national fund ought to be provided for the support of the widows and orphans of parties who meet with their deaths by accident, and the aged.

2445. How would you provide that fund; by contributions from the workmen?—By contributions from the workmen.

2446. When they were in health?—In health, and working.

2447. Similar to the present system of benefit societies?—Similar.

2448. Do benefit societies exist pretty extensively in your district now?—They do.

2449. Are they pretty generally joined by the workmen?—They are.

2450. Can you give the Committee any idea of the amount paid to a man who has been injured by the work, and out of employment; how much the fund would allow him?—The fund I am connected with allows 6*s.* per week.

2451. What contribution would the men pay in order to gain 6*s.* per week?—One shilling and sixpence per month up to 2*s.*

2452. How long would he have to subscribe before he would commence to receive this 6*s.* a week from the fund, in case he was sick or met with an accident?—Only one contribution, one month.

2453. He would immediately become a full member?—Yes; but there are cases of what is called life boxes, that a man entering has to pay a premium of something like 10*s.* or 15*s.* or 20*s.*; but, generally speaking, the yearly funds are dissolved and are recommenced at Christmas.

2454. When they are dissolved the funds are divided among the members?—Yes.

2455. Are the Committee to understand from you that, although the system of funds is pretty general in your district, you do not consider it sufficient, and you would as well, in addition to those funds, recommend that a fund should be established by Act of Parliament, which the miners should be compelled to support, and that they should be allowed a certain sum in case of accident or in case of sickness?—I omit sickness, but provide for the aged and worn-out miners.

2456. Merely in case of accident?—In case of accident or death, for the provision of their orphans and widows.

2457. You consider that the present funds apply sufficiently to sickness; this fund would be solely and exclusively for the provision of widows and orphans of men killed in the works, as well as those who meet with accidents?—I do. I do not wish to take the burthen off the parish; by no means. Though the allowance in such cases is only a starvation allowance, I wish this fund to be applied generally, that is, in all cases of accident and old age in the coal mine. Supposing 33,000 miners in the counties of Northumberland and Durham, at 1*d.*

per week, it will give 137 *l.*; and taking the average offtakes at 3 *d.*, it will give 26,572 *l.* per annum, which I think will be sufficient to meet all cases, with the decrease of accidents by a more rigid inspection.

2458. Have you any further evidence to offer to the Committee?—No, I think not.

Lunæ, 4° die Julii, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Stephenson.
Mr. Fitzroy.	Mr. Mostyn.
Mr. Hussey Vivian.	Mr. Cobbett.
Mr. Baird.	Mr. Locke.
Mr. Cayley.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Mr. *David Swallow*, called in; and Examined.

Mr. *D. Swallow.*

4 July 1853.

2459. *Chairman.*] WHERE do you live?—At Rainford, near St. Helen's.

2460. Are you now employed as the agent of the workmen in that district?—At present I am corresponding secretary; when I was examined in 1849, I was agent.

2461. There is an association there?—Yes.

2462. Will you describe the district?—It is called the Lancashire and Cheshire Branch of the Miners' Association.

2463. Is it connected with the Miners' Association of the North of England?—Only by correspondence.

2464. You are the corresponding secretary?—Yes.

2465. Will you describe your duties?—My duties are to attend to all the correspondence of the society; to direct my attention to the subject of accidents in coal mines, to attend coroners' inquests, and watch the proceedings on behalf of the men, and generally to promote their interests.

2466. How long have you been connected with that society?—I was first appointed agent on the 7th November 1842, and I held the office of agent until February 1852; since that time I have held the office of corresponding secretary.

2467. For many years have you been acquainted with the views of the working people?—For 11 years my attention has been entirely devoted to that subject.

2468. Have you been practically engaged in mining?—I worked 16 years in coal mines.

2469. How long have you ceased to work?—The last time I worked was on the 7th September 1842.

2470. Is that the time you first began to be their agent?—It was some few weeks previously; but I was engaged by men in collieries which I worked at locally, so that I have been engaged ever since the 7th September, but not in the capacity of agent.

2471. Is your practical knowledge of the workmen confined to one colliery, or have you worked at a good many?—I have worked at a good many.

2472. Have you ever worked out of your own district?—Yes, I have worked in some parts of Lancashire, and I have worked at Bradford, in Yorkshire, and Wakefield; principally about Wakefield.

2473. Have you worked in the Northumberland and Durham districts?—No.

2474. You are not practically acquainted with those districts?—No.

2475. You gave evidence before the Committee of the House of Lords in 1849?—I did.

2476. You then went very fully into the question of inspection?—Yes.

2477. You were a great advocate for inspection at that time?—Yes.

2478. Were you party to a Bill which was brought in by Mr. Duncombe and others?—Yes.

2479. Was

2479. Was that Bill rejected?—It was not pressed to a second reading; it was withdrawn upon a promise from the then Home Secretary that if we would not press the Bill to a second reading, the Government would take the subject in hand, and they did so, and the present system of inspection is the result.

2480. Your opinion then was, that the inspectors should have more power than the Act gave them?—Yes.

2481. Since that time inspectors have been appointed?—Yes.

2482. Is it your opinion that their appointment has been beneficial in the prevention of accidents?—I believe it has.

2483. Do you think that the working people themselves are satisfied with the present system of inspection?—It is far from satisfactory.

2484. Can you state why they are not satisfied, and the points on which they express their dissatisfaction?—They are not dissatisfied with the present inspection, so far as it goes; but, in the first place, they think that the number of inspectors is not sufficient.

2485. They wish the number to be increased?—They wish the number to be greatly increased, and their powers to be extended.

2486. In what way do they wish for an extension of their powers?—For instance, the inspectors have no real power; they have only power just to inspect, and report, and suggest.

2487. What power do the workmen wish to give them?—The workmen wish to give the inspector a power, where he finds anything which is really dangerous and wrong, to point it out to the managers and proprietors of mines, and tell them there is an evil which must be remedied by some means or another. We do not wish the inspector to direct the particular method or way in which it should be done, but that he should give a reasonable time to remove the evil; and that if when he goes round again, he finds it is not removed, he should have the power of laying an information before the magistrates, and of calling upon the managers or proprietors to answer for the neglect.

2488. For that purpose, would it be necessary to give the magistrates more power than they possess at present?—Yes; the magistrates have no jurisdiction at the present moment.

2489. Would you, at any time, give the inspectors a power to stop a mine, if it was in very bad order?—Yes, if it was very dangerous indeed; but I imagine that a case of that sort would seldom happen; I think it is a power which must be used with very great caution. I would not give one inspector the power of doing it.

2490. One or two of the inspectors have suggested, that they should give notice to the proprietor if a mine was in very bad order, and desire him to alter it in the way they might suggest; and that if he refused to do so, an arbitration should be appointed. Do you agree that that would be a good plan?—I believe it would; I would not recommend that one inspector should have the power of stopping a mine. We suggested that there should be a number of sub-inspectors, whom the inspector should have the privilege of calling together, and that he should take counsel with them; and that he should, at the same time, have the power of calling some of the inspectors from another district, to take counsel with him also; and that if, after mature deliberation, they found that the mine was really dangerous, he should have the power of stopping it until the danger was removed; but I apprehend that a circumstance like that would seldom happen.

2491. In answer to question 1,062 of the Minutes of Evidence taken before the Committee of 1852, Mr. Darlington says, that your union is almost exploded; is that true?—No; the explosion has been at his colliery. On our present books we have better than 3,000 members.

2492. Your union is not established for the purpose of dictating to the masters any course that they should pursue?—No.

2493. Will you state shortly the purposes of your union?—One of the principal objects is, to get Government inspection of mines; and another is, to protect their wages.

2494. Have you got the printed rules of the union?—No.

2495. Mr. *H. Vivian.*] Are there printed rules?—Yes.

2496. *Chairman.*] Can you furnish the Committee with a copy of them?—Yes, I will send for a copy of the rules, and hand it in.

2497. Do you approve of the mode of increasing the number of inspectors, which has been suggested by Mr. Jude and Mr. Henderson?—Yes.

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2498. That is to say, you approve of the appointing sub-inspectors?—Yes.

2499. From what class of men do you think the sub-inspectors should be selected?—I think that the sub-inspectors should be selected from the most intelligent practical miners.

2500. Do you think that men could be selected from amongst the working men, sufficiently intelligent and sufficiently expert for the office of sub-inspectors?—I believe so. I believe that a great number of miners are directing their attention to that subject at the present time, and are doing a great deal to qualify themselves for such offices.

2501. Do you think that sub-inspectors should have a certain amount of scientific education?—I do not think that would be required for the sub-inspectors.

2502. You think that their being good practical men, and steady men, would be quite sufficient?—Yes.

2503. Do you think that such a class of men could be found, who would satisfy the owners of the colleries, as well as satisfy the workmen?—I believe so. I know that when the inspection was first appointed, there was great complaint among many of the masters in Lancashire. They were frightened, that the persons who were going to be appointed would not be practical men. The general complaint was, "We do not want chemists, or doctors, or railway engineers, lawyers, or anybody who knows nothing of pits; let us have somebody who understands the pits, and who will examine them; and then we do not care."

2504. Do you think that such a class of men as you have described would be rather more liable to be tampered with by the viewers or deputy-viewers of a colliery?—No; not if they were paid a liberal salary.

2505. What do you think is a liberal salary?—I think that if they had 250*l.* a year, it would be a liberal salary.

2506. Who is the inspector in your district?—Mr. Dickinson.

2507. Does he give satisfaction?—He gives great satisfaction to all parties, I believe.

2508. Have the working men confidence in him?—Perfect.

2509. And the owners of mines also?—Yes, for anything I know to the contrary; I know that a great many have, and I never heard any person say anything to the contrary. We have the greatest confidence in him.

2510. Having that confidence in him, you think it would be better to appoint a class of sub-inspectors under the inspectors, than to appoint a class of men of the same calibre and character as Mr. Dickinson?—Yes.

2511. You would not give the sub-inspectors the power of doing anything themselves?—No, I would limit their power.

2512. If they saw anything wrong, you suggest that they should report to the inspector, and that the inspector should himself visit the mine, and that if he had any doubt on his mind he should call in another inspector, and consult with him; and that if those two gentlemen agreed in the plan that ought to be adopted for improving the ventilation, or for the safety of the mine, the inspector should have full power to carry that into effect?—Yes.

2513. Mr. *Baird.*] You do not think it desirable that he should point out any particular method of doing it?—No; I have already said that he should only have the power of saying that a certain thing was required to be done, and leave the manager to adopt his own system of remedying the evil, only it must be done.

2514. *Chairman.*] You do not wish to take any responsibility out of the hands of the coalowner, or to interfere with him in any way further than is actually necessary for ventilating the mine, and keeping it in a state of safety?—We wish to fix the responsibility more closely on the master or manager; it sits very lightly on them at the present time.

2515. You do not wish to interfere with them in the mode which they may think is the best for carrying on their workings in the most economical and proper manner, provided they pay due regard to the safety of the men?—Not at all.

2516. How many sub-inspectors do you think would be necessary in your district?—We are perfectly satisfied that not less than five would be an efficient inspection.

2517. Do you think it is necessary that every colliery should be visited within a certain period?—The collieries in Lancashire and Cheshire vary. We have seams

seams of coal from 13 feet to one foot or 16 inches in thickness; and some of our mines are very fiery, and a great number have no fire at all in them. We have a great many where there are no shafts, and where they drive out of the hill-sides. Our mines vary so much, that I would leave the inspectors and sub-inspectors to determine which mines it was most necessary to visit.

2518. Do not you think that every colliery should be visited within a certain time?—No, it would take a great number of inspectors to do that.

2519. Would you limit their visits to collieries which they considered to be dangerous?—I would leave it to their own judgment, and they would soon find out where it was necessary to visit.

2520. Do you think it is equally important for them to visit collieries where the ventilation is bad, and where no other danger exists than danger to the health of the men?—Yes, it is quite necessary they should visit all; but I do not think it is necessary to visit those collieries as often as the others.

2521. In your district, are there cases of natural ventilation?—I know one such colliery, where there are nearly two hundred men employed, unless there has been a furnace put up since February 1852; there is no artificial ventilation at all.

2522. Is that colliery in a healthy state?—It is in a very unhealthy state.

2523. You think that, although no fire-damp existed, it was unhealthy for the men?—Very unhealthy; in fact, the black-damp is more fatal than the fire-damp.

2524. Are you of opinion that, by a legislative enactment, some system of artificial ventilation should be adopted in every mine?—In all mines, whether fiery or not.

2525. Since you gave your evidence in 1849, have you found that there have been any improvements in the management of collieries?—More attention has been paid to the air-ways and to the furnaces; and in some places, where there was no furnace, furnaces or fire-grates have been introduced. In mines with which I am acquainted, there has been some apparatus or another put up, for artificial ventilation, where there was none previously. The stoppings and doors have also been better attended to.

2526. Do you attribute that improvement to the inspectors?—Yes; I know that as soon as the Act was passed a great many of the overlookers received instructions to put the pits into repair, and attend to what was necessary; because it was said, "We shall be having these gentlemen among us very quickly, and you must get things into order immediately, for we cannot tell how soon they may come.

2527. You stated, in 1849, that you would not in any case enforce any particular mode of ventilation, but that you would rather require that sufficient ventilation should be afforded; is that still your opinion?—Yes.

2528. Supposing that by natural ventilation it was found that sufficient ventilation existed in a pit, and that a pit was perfectly safe and healthy, you would not by legislation enforce any further ventilation?—No; but natural ventilation is impossible, if a pit is worked to any extent; if it is only a small pit with ten men in it, no ventilation that I am acquainted with, supposing there is no fire-damp, can make it anything like healthy. I have left pits where the work suited me, with that exception, and where the air was so bad that my health was so injured that I was compelled to leave the colliery, and work in pits where there was better air.

2529. Mr. *H. Vivian.*] Assume that the air was not bad?—I am not acquainted with any pits in Lancashire, where we have not either fire-damp or black-damp.

2530. Assuming that was not the case, you would not bind people down to any particular mode of artificial ventilation?—That is a thing with which I think we are not acquainted; at least I am not acquainted with it, and therefore I cannot speak to it. In all mines that I am acquainted with, there is damp of one sort or another.

2531. *Chairman.*] Is there better ventilation at the present time than there was in 1849?—There is a general improvement. More care and attention is paid to the stopping, but not sufficient care and attention.

2532. Mr. *Cobbett.*] Do you attribute that improvement to the inspection?—Entirely.

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2533. *Chairman.*] You stated in 1849 that you did not believe too much air could pass through a mine?—I believe that also, now.

2534. Then you do not believe that (as some of the witnesses stated to the Committee of 1852), there could be too much air passing through a mine?—No.

3535. You never heard a collier complain of having too much air?—No.

2536. Did you ever hear him complain of the candle swealing?—Yes; but we can easily protect ourselves with a tin or wooden case.

2537. Mr. *Cobbett.*] How much air ought each man to have?—I perfectly coincide with Mr. Blackwell's Report of 25th March 1850, in which he says that each person ought to have 250 cubic feet per minute, supplied to him in mines which are not fiery, and up to 500 cubic feet per minute in mines which are very fiery. I believe that any less quantity than that is not sufficient to protect the health and lives of miners generally. I think that may be taken as something like a safe standard.

2538. *Chairman.*] Do you mean per man?—Yes.

2539. Mr. *Cobbett.*] Do you conceive that it should be made compulsory on the part of managers of mines to supply that quantity?—Yes.

2540. By legislative enactment?—Yes, I think it ought to be so.

2541. *Chairman.*] Do the colliers agree with the Report of the Committee of 1852?—They do generally, but there are some little things that we do not understand.

2542. Will you explain in what points you disagree with them?—We agree with them generally as regards the safety-lamp not being exactly the safe thing it is represented; we believe it is a very dangerous instrument, and that it has allured a great many people to danger and to death.

2543. Do not you believe, that if proper care were taken of the safety-lamp, it is safe, except under very peculiar circumstances?—I believe it is safe if proper care is taken; but there are so many "peculiar circumstances" connected with it, and there are so many ways in which it may become disarranged, that it is almost impossible it can be kept in a proper manner, for a man to work with it regularly without some of those peculiar circumstances happening to it.

2544. Mr. Jude and Mr. Henderson, in their evidence with regard to the safety-lamp, stated that in certain cases where the pits were very fiery, safety-lamps should be compulsorily used; they also stated that, provided it was necessary to use safety-lamps, it should be incumbent on the owner of the mine to have a sufficient number of men to take care of those safety-lamps, and keep them in order; and that it should be also incumbent upon them to have as many men as were required, whose special duty it should be to clean the safety-lamps, put them in repair, put oil in them, look after them, and keep the keys under their own care: with all these precautions, do you think that the safety-lamp is unsafe?—I quite agree with them in their remarks; but I believe that a safety-lamp is a very dangerous instrument to be trusted in the hands of workmen and boys. I do not consider it is any real protection, as the circumstances under which it may and does become disarranged are common, and not "peculiar."

2545. Have you seen the glass safety-lamp?—Yes; but I have not had experience of it.

2546. Do you consider it answers as well as the Davy lamp?—Yes; to the common Davy lamp.

2547. Is your great objection to the Davy lamp, that it is liable to explode, if a blower or a current of air passes through it?—Yes.

2548. Provided a lamp were invented which prevented a blower or any air passing through it, and gave sufficient light to the workmen, would your objection be removed?—I believe that, generally, the safety-lamp has a tendency to give confidence to the men and the masters that it is a safe instrument, and that they have neglected a great deal of precaution which otherwise would have been taken.

2549. Mr. *H. Vivian.*] Assuming that the colliery is well ventilated, do not you consider that the use of the safety-lamp would make that colliery more safe than the use of naked lights?—In case of a sudden outburst of gas, or any sudden irruption of that sort, it would make the colliery more safe.

2550. Are there not always points in a colliery, however well ventilated it may be, at which a naked light would cause an explosion?—I believe that may be

be the case in some collieries; but I do not know that if a colliery was properly ventilated it could be the case. I believe all parts of a mine, except the goaves, can be sufficiently ventilated without there being real danger.

2551. Mr. *Stephenson.*] If a fall should take place in the goaf, would not the fire-damp be expelled into the working parts of the mine; and if candles were used, would not an explosion inevitably take place?—Undoubtedly.

2552. In such mines, would you not take the precaution of working with safety-lamps?—Yes; in the immediate neighbourhood of the goaf.

2553. *Chairman.*] Provided every care were taken to ventilate a colliery in the most efficient manner, does your answer apply to the safety-lamp, or is your answer confined to the opinion that the use of the safety-lamp encourages the owner of a mine to pay less attention to ventilation than he otherwise would?—I believe that if a mine is properly ventilated, a safety-lamp is not required, except in the neighbourhood of the goaves.

2554. Mr. *H. Vivian.*] May not certain irregularities, which it is utterly impossible for any human foresight to provide against, render a portion of the mine explosive?—We have read of that in the north of England, but I never heard of an instance in Lancashire and Cheshire.

2555. Your remarks apply to your own district?—Yes.

2556. You have no experience in large fiery mines in the north of England? Not at all.

2557. What is the largest production of coal from any mine with which you are intimately acquainted?—I should think that the Ince Hall collieries are producing as much coal as any mine in Lancashire; there are firms which produce more, but they have more shafts.

2558. What does the Ince Hall colliery produce?—I cannot say exactly.

2559. Two hundred tons a day?—More than that a great deal, from one shaft; but I would rather not speak on that subject, because although I have often been at the Ince Hall colliery, it is no portion of my business to inquire into that subject.

2560. *Chairman.*] Do you think it is possible to put down bore holes, and maintain bore holes on the goaves?—I think it is possible to put down bore holes, but I do not think it would be wise to do so.

2561. It is not a system you would recommend?—No.

2562. Then in that respect you do not agree with the Report of the Committee of 1852?—No.

2563. Do you agree with the Report of the Committee of 1852 as to refuge stalls?—I think it is very good if it could be carried out.

2564. How would you get the air to the refuge stalls, provided the brattice or the doorway were blown away by an explosion?—Although I am not going to advocate it, or say anything against it, the way in which I understand it is, that refuge stalls would be made something like a room at each side of the main air road, and that there would be some sort of door, the same as the valve of a pump, and that when an explosion took place it would bear on the valve, and the men would only have to open it and go through, and, as a matter of course, the room or stall would be full of atmospheric air, and that as soon as they got in the door would immediately shut, and keep the choke-damp out. If the room were large enough to supply the men with pure atmospheric air until they were rescued, it would be safe; but if it was not large enough, so that by continual breathing the air became impure, it would be no better than being in the other place.

2565. Have you ever calculated what space or area would support a man for a certain number of hours?—No; the refuge stall is a thing we have taken little notice of.

2566. Looking at the question in a practical light, do you think it would be possible to have refuge stalls?—It is a subject I do not understand.

2567. Mr. *Stephenson.*] Did you ever go into a colliery after an explosion had taken place?—Yes.

2568. Immediately?—Not immediately; I have assisted in making repairs after an explosion.

2569. Did you take air into the pit where the explosion had taken place, in order to extricate the men?—The rule generally, when the stoppings are blown down, is to get them up again as fast as you can, and take the air with you.

2570. When you came to the unfortunate men who were killed by the after-

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damp, did you find them very far from the place where they had been working?—In that case they were not far from the place where they had been working, because the explosion was a very serious one.

2571. Were the men burnt?—Yes.

2572. *Chairman.*] Do you think that more efficient means than refuge stalls could be adopted in mines?—I am not aware of any; if the refuge stall is made sufficiently large, it is quite possible that it may be of use; but as it is a subject which has never come before the men, and I have not paid attention to it, I would rather say nothing about it.

2573. Mr. *Locke.*] Supposing that refuge stalls were found to be efficacious, in your judgment how far ought they to be from the place where the men are working?—In many cases we have found that the men have got a long way from the place where they have been working; for instance, at the Ardsley Maine, near Barnsley, I was sent over by the men from Lancashire to attend an inquest, and I made full inquiries into the matter, and I attended the coroner's inquest with an attorney on behalf of working men, and I found in that case a great number of the men had got a long way towards the pit shaft; in fact, many of them were very near at the shaft.

2574. Were those men killed by the after-damp?—Yes, and they were not burnt at all.

2575. Is it your opinion that, if refuge stalls had been made, those men might have been saved?—I cannot offer an opinion upon whether they might or not have been saved.

2576. If any refuge stall had been placed near where the men were working, do you think that they would have been as likely to be destroyed?—There might have been a probability that if there had been a sufficient space to hold any quantity of atmospheric air, some of the men might have been recovered.

3577. Do you know how many men were destroyed in finding their way towards the shaft?—Seventy-three were killed in the whole; I think that something like nineteen were found altogether, but very few of them were found in the boards; in fact, they had no boards there; they were found in the workings; there were very few of them who could not have got into the air-passages, if there had been any.

2578. Mr. *Stephenson.*] Were they on the up-cast side, or the down-cast side?—The up-cast and the down-cast were both together; I cannot say whether they were in the return air-way or the intake.

2579. *Chairman.*] How long was it before any fresh air was brought into the working?—The pits were so near together, that the partition between them was blown down.

2580. Mr. *H. Vivian.*] That was a brattice shaft?—There were two shafts; they were very near each other; and when the explosion took place it blew a hole right through.

2581. It blew a hole between the two pits?—Yes.

2582. Where no hole existed previously?—Yes.

2583. Then it blew the rock down?—I think it was soft metal.

2584. It blew the metal down between the two pits?—Yes.

2585. Assuming that explosion had taken place, and that the ventilation had continued round the mine and air-ways, although the bratticing in the stalls might have been blown down, would those men have been destroyed?—The great majority of the men would have been saved at that time.

2586. Then in your opinion, the main point is, to prevent the possibility of the main current of air being stopped in a colliery?—Yes.

2587. In the majority of explosions, does the great loss of life occur from main doors or other stoppings, between the intake and the return current being destroyed, whereby the passage of the fresh air round the remote workings is prevented?—I believe that is the case.

2588. So that it is desirable, as far as possible, to avoid such weak places in a colliery as main doors?—Yes.

2589. May that be done by a wall carried out to stop the working?—That might be done by having a shaft at the extremity of the working.

2590. Or by coursing in the stone?—Many of the heavy explosions, unless they went a good way above or a good way below, would find their road to the weakest places.

2591. They

2591. They might be 10 yards or 15 yards?—Yes; I believe that less than that would be sufficient to protect them from being blown down.

2592. *Chairman.*] Another point in the Report of the Committee of 1852 is, that by an instrument called a self-registering anemometer, the inspector would know at each visit the rate at which the current of air had been passing through a mine in his absence. Have you any knowledge of the anemometer?—I know something about it. It appears that it cannot be moved sufficiently to give any certainty. There is a great deal of difference in them; and they have not sufficient delicacy in them to be a test of the real quantity of air passing along.

2593. Supposing an anemometer were made with the greatest delicacy, do you think that a dishonest viewer could, if he pleased, deceive the inspector by passing the air through a smaller place, and making the anemometer go faster than the ordinary rate of the current of the mine?—Yes, that could be done; but I do not apprehend that would be generally done.

2594. In that case you would not make a self-registering anemometer a test of the ventilation, and a register for the inspector?—No; in fact I do not think, with the experience I have had of it, that it can be made any test at all.

2595. You stated in 1849, that you did not perceive any use in splitting the air into different currents; have you altered your opinion in that respect?—My opinion has undergone some little modification; I should wish to have a good current of air all round the working, and at the same time I should wish to limit the extent of working in each shaft.

2596. Did your answer apply to having more shafts, more intakes, and more up-cast shafts?—Yes.

2597. Provided it was not possible to have more than a certain number of down-cast shafts and up-cast shafts, in your opinion would it not be better to split the air into different currents, so as to give every man in the mine as much as possible a current of fresh air for him to breathe, and that had not been used by the other men?—I think that each man ought to have his own proportion or share of fresh air.

2598. That answer involves splitting?—Yes; but not exactly splitting in the way it is generally carried on.

2599. Will you explain why it does not involve splitting in the way it is generally carried on?—The way in which air is split generally in Lancashire is, that as soon as it gets down to the bottom of the down-cast shaft, it goes along a principal road, and then it branches off to one portion of the district and ventilates it, and then returns; and so it is in all the various districts.

2600. And the same current ventilates the whole district?—Yes.

2601. In that case the air is not split at all?—Yes, there may be ten splits; there may be ten districts in a pit.

2602. Mr. *Locke.*] If that is the practice in Lancashire, how do you accommodate all those ten districts without splitting the air?—In one pit in Lancashire with which I am acquainted, there are ten splits. It is quite possible that there may be in one district 10 or 40 men, and it goes the round of the whole of the men; so that, when it comes to the last, the air is loaded with the gas which is taken along with it, and is almost unfit for the men to live in.

2603. You have been understood to state, that you thought all the men ought to have an equal share of fresh air?—Yes.

2604. Would that state of things enable the last man to get his fair share of fresh air?—Yes.

2605. You stated that the air was scarcely fit for him to breathe?—I mean in the way it is practised now.

2606. How would you avoid that danger, without splitting the air?—Supposing there is a district where there are 40 men; the way we work in Lancashire is best laid out in Mr. Blackwell's plans; that is, the air is coming up the main air-way, and, provided there are ten men working up one set of bays, I would take one portion of the air to those men, and let it ventilate the place in which those ten men were working, and immediately return back; and when it gets to the next set of bays, one portion taken off to them, and immediately let it go back to the up-cast; and so on with the third and the fourth.

2607. What is the difference between that mode and the present mode of splitting the air?—The present mode is, that it begins with one and goes the whole round of the district.

2608. In those cases there are several districts?—Yes.

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2609. Supposing that those who advocate the splitting of air were to have ten men in a district, you would then be under precisely the same circumstances? —Yes.

2610. Then, in point of fact, your mode of dividing the 40 men into companies of 10 each, and giving to each a portion of air, is splitting it into four portions?—Yes; but it is not taking the whole to every one of the men.

2611. Mr. *H. Vivian.*] It is not coursing the air?—No.

2612. Mr. *Stephenson.*] Do you mean that in some of the Lancashire collieries the air first passes into one bay, then into the second, and the third, and the fourth, and so on to any amount, before it returns to the up-cast shaft?—Yes.

2613. Are there any large collieries in Lancashire so worked?—There are some, if we must rely on the maps and plans; and the men tell me that it is the fact.

2614. You do not know it of your own knowledge?—No.

2615. Have you ever worked in a mine, where the air passed out of one bay into the other, and so on through the whole mine?—Yes.

2616. In a large mine?—A mine with 30 or 40 men.

2617. Is it not very important to draw a distinction between a system which is applicable to a large mine, and one which is applicable to a small mine?—Yes.

2618. With 30 or 40 men in a pit, what quantity of coals would be raised per day?—On an average, a man would get from three to four tons a day.

2619. *Chairman.*] In order to carry the air well through the workings, is it your opinion that great care should be taken to have sufficient air-ways?—Yes; I think that is a very important point.

2620. Have you formed any judgment upon what should be the area of the air-ways?—I believe that the area of the air-ways in no place ought to be less than either of the shafts.

2621. Mr. *H. Vivian.*] Some of the air-ways?—All the air-ways included. Of course the first intake air, previously to the air being split, ought not to be of less area than the down-cast or the up-cast. Of course they are not compelled to take them in one road; they may have two or three, if they please; but it ought to be compulsory that they have sufficient when it is split, they should still have the same air as before; if it was split in ten different parts, they might have a split one-tenth less than the first intake.

2622. Should the addition of the areas of the whole intakes be at least equal to the area of the shaft?—Yes.

2623. *Chairman.*] Do you think there is at present sufficient care to keep the diameter of the air-ways sufficiently large?—I believe they are too small generally.

2624. Do you think that the air should pass through the goaves, or that the goaves should be kept closely stopped?—I think that the air should pass through the goaves, if it is possible; but I do not see how it is possible at all times, and under all circumstances.

2625. Do you think that the goaves should be tightly stopped, and sufficient air go round them to drive away any foul air which might escape out of the goaves?—I do not agree with trying to keep the gas in the goaves at all; I think it ought to be got out as soon as possible.

2626. Did not you state that it was impossible to ventilate the goaves?—I am not aware of any means at present of ventilating them properly; but there are means whereby it may drained off to a considerable extent.

2627. Are you not aware that a certain quantity of air admitted into the goaves, which would not properly ventilate them, would have a tendency to render them much more highly explosive than they would be if no air went into them?—I am aware that coal-pit gas will not explode, unless it is mixed with a certain quantity at atmospheric air.

2628. Admitting, as you do, that it is impossible to clear the goaves of gas, is it not your opinion that it would be less dangerous to stop the goaves as tightly as possible, to prevent any atmospheric air passing, than to let an insufficient quantity of air in to clear the goaves entirely?—Yes, if there were any means whereby they could be stopped up; but I do not know how that could be done, because when the men are getting the pillars, or anything of that sort, they are compelled to have the goaves open. When a district was worked out, they might make it clean off, and then I should have no objection to its being made clean off; but so long as the men are working on the edge it cannot be done.

2629. As

2629. As you say that it is impossible to ventilate the goaves thoroughly, do not you think it is better to endeavour as much as possible to keep the gas in?—No.

2630. Would you allow a certain portion of fresh air to go in and mix with the gas in the goaf?—The best mode of ventilating a goaf with which I am acquainted is, that previously to the pillars being worked out there should be ample air road all round, and that a sufficient quantity of coal should be left to the rise of the return air road, and cut through it every 20 yards all the way round; and when the men are bringing the pillars back, if we drive a good air into the place where the men are working, it will naturally have a pressure upon the goaf, and have a tendency to work the gas out; in fact, the gas will rise of itself according to its own gravity, and will have a tendency to make its escape at the top, and the air pressing behind will have a tendency to assist it.

2631. Mr. *Locke.*] What is the extent of a goaf, generally speaking, in the Lancashire collieries?—We are getting some very extensive now.

2632. How large in width?—I can hardly speak to the exact size of them; but some of the pits embrace a great number of acres.

2633. How far are they working their mines in Lancashire away from the pits?—The very extensive mines they are generally working now on the north country plan, and therefore they may make them any size; there is no regular rule what size a goaf should be.

2634. On the Lancashire plan?—The pits are generally not very extensive, and the Lancashire plan is quite different from the north country plan.

2635. Where the goaves are extensive, and where they work on the Lancashire plan, are the pits a quarter of a mile or half a mile apart?—A great deal more than that.

2636. A mile?—I do not know. They are getting a vast quantity of acres to each pit.

2637. What is the distance that the air is carried through the working under ground, where it is half a mile from the pit?—I have asked that question at some of the inquests, and the managers themselves generally do not know; they say that some of them are at a great distance.

2638. Have you any a mile long?—I believe there are some more than that.

2639. You do not know the width of the goaf?—No, I have often tried to get the length of air passages at coroners' inquests from the managers, but they seldom knew anything about it.

2640. Would not the plans of the colliery show it?—I do not know that they would, because many of them have no scale to them.

2641. Are not all colliery plans drawn to a scale?—I do not know that they are.

2642. *Chairman.*] How could they be plans at all, if they were not drawn to a scale?—I have seen some plans which had no scale to them.

2643. Mr. *Locke.*] Are they not drawn to a scale from which any person knowing the scale could measure for himself?—I do not know how they were drawn; I did not ask that; I know the scale was not on them.

2644. Mr. *Stephenson.*] Are you familiar with the mode of laying down plans of mines?—I am not familiar with making plans, but I understand a plan; and if I see a plan and see the scale, I can soon tell the distance, and so on.

2645. If you saw on a plan a series of bays, as you call them in Lancashire, would you be able, knowing the width of a bay, generally speaking, to get a scale, supposing you were a perfect stranger to the mine?—Yes, if I knew they were in the habit of having them 10 yards wide, and so on.

2646. Would not that be a very good standard for you to go upon, supposing, as you state, there was no scale put on the plan?—Yes.

2647. *Chairman.*] Do you think that the principal air-ways should be independent, and not used for drawing coals?—Yes; I think that the principal air-ways ought not to be interfered with for drawing coals.

2648. How many air-ways do you think there should be in a pit?—That is one of the things which ought to be left to the manager. I think that we ought not to say how many air-ways there should be, but that we ought only to say they should be of sufficient size.

2649. You would have the intake air-way, and the air-way for the return air, totally independent of the roads which are used to waggon the coals along?—Yes.

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2650. Mr. *Cobbett.*] When you say that the air-ways ought to be of sufficient size, is the rule that you go by the size of the shaft?—Yes.

2651. *Chairman.*] What ought to be the size of the shaft?—That depends on the quantity of men in the interior of the mine. Supposing that I was going to sink a pit and employ 200 men, I should have my shafts accordingly.

2652. Would that answer also refer to the number of shafts?—Yes.

2653. Mr. *Stephenson.*] Does not the quantity of air going down a shaft depend very much on the temperature of the up-cast?—Yes.

2654. Then if you are going to sink a shaft for a given number of men, must you first of all determine what furnace power you will make use of?—That is a principal consideration; but it is generally understood that there is a limited power to the furnace, and that we can get very little more than 1,000 feet per minute, per foot area. It is exceeded occasionally, but we take that as a standard rule.

2655. Would not that depend on the extent or the length of the course of air through the mine?—Of course; and upon the efficiency of the furnace; but where there is one pit which gets more than 1,000 feet per minute per foot of area, I think we may take it for granted that there are 100 which do not come up to that point by a great deal.

2656. *Chairman.*] Do you think there should be ever less than two shafts in a mine?—No.

2657. You think it should be compulsory on a coalowner to sink two shafts in his colliery?—In all cases.

2658. What number of acres do you think should be allowed for a shaft?—I think that something like 40 statute acres is quite enough to one shaft.

2659. Would not that depend, in some measure, on the nature of the seam?—Certainly.

2660. Mr. *Locke.*] Would the depth of the mine alter the circumstances at all?—Certainly, it would cost more to sink another shaft where the mine was deeper.

2661. Do you know, in the north of England, what distance or what area they generally work from a mine 300 yards deep?—They work great quantities, and far more than is safe.

2662. Do you think that one of the disadvantages of the north country system is, that they work too far from the first shaft?—Yes.

2663. Would you limit them to 40 acres in a pit of that kind?—Not in a very deep pit like the Monkwearmouth, but generally speaking, for all useful purposes, and particularly in the Lancashire coal-field and the Yorkshire coal-field, they will not come to anything like 200 yards; and on the average, in coal pits in Lancashire, second shafts are sunk very cheap.

2664. What do you mean by "second shafts"?—We should have two shafts to the dip; after we had worked nearly our quantity, we could hollow the other, and supposing there was any water troubling us, we could bore it down; we should have a pumping-engine at the dip. Sinking a second shaft is altogether different from sinking a new pumping pit.

2665. Do you know what is the expense of sinking a second shaft?—I would say 1,500 *l.* for a shaft 200 or 220 yards deep.

2666. *Chairman.*] Your evidence is confined exclusively to your own district?—Yes.

2667. Mr. *Locke.*] The pit at Monkwearmouth is 500 or 600 yards deep?—Yes.

2668. To what extent, in such a mine, would you permit men to work in the same shaft?—In a mine like that, I can hardly state. There is a great deal connected with that mine; but the sinking of another shaft, supposing that any great quantity of coal is got, would be better.

2669. You have considered this question?—Yes.

2670. What distance would it be necessary to work from the shaft in any one direction, in order to get 40 acres for a pit standing in the middle of it?—That would depend entirely on the shape of the coal.

2671. Supposing that all things were favourable, do you recollect what must be the length and breadth of a colliery, to enable you to work 40 acres?—Supposing that the coal laid all to the rise, and spread out on each side, sinking the pits on each side of it would be no great distance to go across it.

2672. How far?—It is quite possible it may not be above 500 yards in a case like

like that; at the same time, it is quite possible that if the royalty was narrow, and extended out as some do, it might be more than a mile in some cases.

2673. Can you state how much it would take in width to make up 40 acres, with only 500 yards away from the shaft?—No, not at the present moment.

2674. Are you aware that the coal would be more than 100 yards wide?—Yes; I should fancy that it would be a great deal more.

2675. Perhaps it would be 200 yards wide?—More than that, a great deal.

2676. How much do you think it would be?—I cannot say just now, but it would be somewhere near 400 yards.

2677. What would be the width of a working in a colliery 500 yards long, in order to make 40 acres?—I have said that I do not recollect just now; it may be easily calculated.

2678. According to your notion, a colliery which is working 500 yards long, might be worked with safety; and you think that a colliery of that kind might be worked with equal safety 200 or 300 yards in width?—Yes.

2679. And you think there are cases where, with perfect safety, a colliery might be extended more than 500 yards from the pit?—I do not think it would be safe; nor is it the interest of proprietors to do so.

2680. Are you prepared to state, that you would limit all coal proprietors from going more than 500 yards?—I do not know that I would limit them, because it would depend on the width of the coal.

2681. Supposing it was a very large coal-field, and you were not restricted, what distance ought a colliery proprietor to be entitled to work from one shaft, before he was obliged to sink another?—I do not know that we could say exactly the distance.

2682. I put the question to you before in reference to the 500 yards?—I think that 500 yards would not be the average, taking all the coal-fields.

2683. *Chairman.*] Each side of the shaft?—Yes; straight forward.

2684. Supposing that 500 yards long by 200 yards wide, instead of representing 40 acres, represented 150 acres, you would not find the same objection?—No, but it does not represent anything of the sort.

2685. Then your answer as to 40 acres may be taken as qualified?—Yes, so far as 500 yards straight ahead goes.

2686. Mr. *Stephenson.*] Do you know the Ravenhead colliery in Lancashire?—Yes.

2687. Is it an extensive colliery?—I cannot speak to that; it is a colliery which has been working a long time, and there are a good many men employed in it.

2688. Do you know that in that colliery they are now working coal at a distance of 2,600 yards from the shaft?—No; none of the men ever told me that.

2689. Have you ever made any inquiry about that?—No.

2690. Do you think it would have been useful information for you to have known before you gave your opinion as to 500 yards from the shaft being the limit of safety; that there are mines in your own district in Lancashire where the coal is worked 2,600 yards from the shaft without any great danger?—I do not know that they are working there without any great danger; I can tell you something about the Ravenhead mine.

2691. Would the knowledge of that fact at all modify your opinion respecting the distance at which coal might be worked from the shaft?—No.

2692. Do you remember any accident at that colliery within the last few years?—No.

2693. Would not that fact rather tend to modify your opinion about the test of safety?—No, it would not.

2694. Would not the fact that the colliery has been worked for several years without any serious accident, and that coal is now got at a distance of 2,600 yards from the shaft, modify your opinion?—No; there is one thing which I wish to state about the Ravenhead mine. The men have often complained to me about the ventilation in many parts of the Ravenhead mine; they never told me the extent of the mine, but I have heard of a great number of complaints. In some parts of that mine the old goaf was on fire, and a good deal of nauseous gas was given off, and they had not sufficient air to make it anything like healthy for the men to work in it.

2695. Is there any fire-damp in that mine?—I think there is.

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2696. If that mine has been worked for several years without accident, in spite of fire-damp, would not that fact rather influence your opinion about the extent of safety?—No.

2697. The fact of the existence of fire-damp in that mine, and its having been worked for some years without accident, would not influence your opinion about the distance at which coal may be got from the shaft?—It is possible that it may have been free from accidents, and yet have been on the verge of them every moment; my plan is rather to prevent the occurrence of accidents.

2698. In this particular colliery, as you state, accidents may have been very near, but they may also have been far off; you do not know the condition of the colliery, and, therefore, you must not make the assumption that it has for years been on the verge of an accident?—I have stated one condition of that colliery; that is, that it is in a very unhealthy state.

2699. Have you been in the colliery?—No, but the men tell me whether the mines are healthy; and therefore in my official capacity they have told me that the mine was not healthy, and have complained to me personally about it.

2700. Mr. *Cayley.*] What is its effect upon them?—On account of the black-damp and the burning of the old goaf, there is not sufficient air to carry it off; and the men complain very much indeed.

2701. This mine seems to be full of choke-damp and fire-damp?—The men have complained very much of it.

2702. The choke-damp is that which affects their health?—Yes.

2703. Have you ever heard them say whether it was very fiery?—No.

2704. May it be more or less fiery?—Yes.

2705. If it were less fiery, would there be less chance of an explosion taking place?—As a matter of course.

2706. And still it would be very unwholesome for the men to live in it?—Yes.

2707. *Chairman.*] You have stated that in your opinion a second shaft, from 100 to 150 fathoms in depth, could be sunk for 1,500*l.*?—Yes.

2708. To what district were you alluding?—The Lancashire and Yorkshire districts.

2709. Have you been practically acquainted with the sinking of shafts?—A little; I once worked for six months in sinking shafts.

2710. Mr. *H. Vivian.*] Did you ever see an owner's account of the cost of a 100 fathom shaft, made up?—I know what the workmen receive, and I have a good notion of what the other labour and material costs.

2711. To what size shaft are you alluding?—Ten or eleven feet diameter.

2712. Do you know, of your own knowledge, of any shaft having been sunk at the price of 10*l.* a fathom?—Yes; 10*l.* a fathom would sink a second shaft, on an average, including all materials.

2713. Mr. *Stephenson.*] You have stated that you attach very little importance to the Davy lamp?—Yes.

2714. Do you know any well authenticated instance where an explosion has been traced to the Davy lamp?—I know a case where a fireman was in the pit by himself, and an explosion took place; he said he was travelling the air-roads with the safety-lamp.

2715. Did he escape?—He was very badly burnt, and he is a cripple, and will be so all the days of his life.

2716. Mr. *Cayley.*] No one else was in the mine?—No one else was in the mine.

2717. Was the lamp locked or shut?—Firemen always have keys, so that if they are locked they can unlock them; we have only his own word that the lamp top was on.

2718. Mr. *Locke.*] Was the man badly burnt?—He was badly burnt.

2719. Was he afterwards discovered in the mine?—He was able to get out himself.

2620. Did he bring his lamp with him?—Yes.

2721. Did he ever tell you that his lamp burst, or exploded, or was injured?—No; it was neither burst nor exploded.

2722. Then, in point of fact, according to the appearance of the lamp, there was nothing the matter with it?—According to the appearance of the lamp, it was all perfect.

2723. And you believe that the explosion arose from the lamp?—I have only his statement for it.

2724. You state that the lamp was in a perfect state when it was filled?—It appeared to be perfect, and I believe that the explosion did take place with the lamp; I have no reason to doubt the man's veracity.

2725. You have given this as an illustration of an explosion which actually took place from the lamp; and you do it from the fact that there was no other person in the pit than the man who was carrying the safety-lamp?—Yes.

2726. You assume there was no other light in the pit than that safety-lamp?—Yes.

2727. Do you believe that explosion took place from the lamp, the lamp being in a perfect state?—I believe it took place with the lamp, but whether the lamp was in a perfect state or not I cannot say.

2728. You were understood to say that when the man brought his lamp out of the pit it was in a perfect state?—To all appearance, it was in a perfect state.

2729. Mr. *Cobbett.*] Did you examine it?—No.

2730. Mr. *Locke.*] Did anybody examine it?—Yes; the man said that he believed his lamp was perfect, and he says so now; I know nothing to the contrary.

2731. Did the man believe himself that it took place with his own lamp?—Yes.

2732. *Chairman.*] Did he say that he had not taken off the top of the lamp?—Yes.

2733. Do you think that he would be afraid to tell you if he had taken off the top of the lamp?—He could have no interest in trying to deceive me, because all these things are generally told me in confidence.

2734. Would not the other workmen, if they knew he had taken off the top of the lamp, be very much annoyed?—They would have been very much alarmed.

2735. Mr. *Locke.*] Do you know of any other case?—No.

2736. Then from that one case you think the Davy lamp is unsafe?—I believe it from demonstrations which I have seen; for instance, if we take the Davy lamp at the common gas, if it is on at a high pressure it will explode; I have seen it exploded a hundred times with a common gas burner.

2737. Mr. *H. Vivian.*] At a very high pressure?—Supposing there is a common gas burner, you can explode the Davy lamp.

2738. Would there not be a strong current of gas rushing through the lamp?—Yes.

2739. Are you aware that the inventor of the Davy lamp stated, when he brought the lamp out, that such was the case?—I have seen that, and the first time I saw it, it alarmed me a great deal; I had perfect confidence in the Davy lamp previously to that; and when I saw it in a private dwelling experimented on a hundred times in that sort of way, my confidence in the Davy lamp was entirely shaken, and is so to this day.

2740. Is such a condition likely to occur in the ordinary practical working of collieries?—Yes.

2741. Do you think that in collieries gas will issue at the velocity at which it issues from a gas burner?—Supposing that gas does not issue at that velocity, there are other circumstances which may arise.

2742. What are those circumstances?—Supposing that a man was working in a straight place, and he was not aware that the lamp was full of fire, and when he turned round he saw that his lamp was full of fire, and he incautiously took his lamp and pulled it quickly to him at a quicker pressure than the lamp was able to bear, an explosion might take place.

2743. *Chairman.*] Supposing a man had been in that place with a naked candle, what would have been the result?—The man would have been burnt.

2744. Then, in that case, would he not have had more chance of being safe with the Davy lamp than with a naked candle?—Yes; supposing there is a sudden fall from the roof, which causes the gas to travel above a certain rate, the lamp will explode. It is quite possible that the most careful man, when he is cleaning his lamp, may just disturb one of the wires; and if one of the wires is knocked a little out of its place, and the lamp fills, it is perfectly insecure.

2745. You were asked, in the early part of your evidence, whether you did not think it necessary, if safety-lamps were used, that one man should be employed

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at the top of the pit; or if one man was not sufficient, that a sufficient number of men should be employed, whose exclusive duty should be to clean the lamps, examine whether they were in proper repair, and to repair them if they were not in proper repair; you were understood to state that that was necessary?—Yes.

2746. And being necessary, would it not be likely to obviate the objection you state, as to the wires being out of order?—No; because a little bit of coal or anything else might disturb one of the wires; and then, again, safety-lamps are generally put into the hands of young boys. Supposing I was a collier, and had a boy, I would take him into a pit, and the safety-lamp would be put in the boy's hands, and the boy would know nothing about it; labourers come over from Ireland, or any one else, and the lamp is put into their hands; they know nothing at all about it. The lamp is a very delicate instrument, and ought to be used with great caution.

2747. Are the Committee to understand that if you could not work a pit with candles, that you would stop the pit—No.

2748. Supposing you could go into a pit, and work it with safety-lamps until sufficient air was got to make the pit pretty free, would you recommend working with safety-lamps, or a cessation of working altogether?—I would recommend working with safety-lamps, but with very great caution.

2749. Then are the Committee to take your evidence merely to the extent, that safety-lamps are advisable only with the greatest caution?—Yes, with the very greatest caution.

2750. Mr. *H. Vivian.*] And that they are not to be relied on?—No.

2751. And that the best ventilation is to be kept up, which it is possible to keep up, but that as an additional means of safety, it is your opinion that the safety-lamp ought also to be used in fiery mines?—Yes, near the goaves.

2752. Mr. *Cayley.*] Was the man whose lamp ignited, a fireman?—Yes.

2753. Is it not the business of a fireman to precede the workmen in a pit, in order to test its safety?—Yes, he was doing that.

2754. Would a fireman have any object whatever in taking off the top of his lamp, if he was going on an exploring expedition, merely to test the safety of the mine?—I know of none.

2755. And therefore you are still of the opinion which you have gathered from the man, that there being no other light in the mine the Davy lamp did not prove a sufficient security against explosion?—Yes.

2756. *Chairman.*] Did the man state that he was walking very fast?—No.

2757. Did he state that he met with any extraordinary current, or any blower?—He was walking against the current at a moderate rate.

2758. Mr. *H. Vivian.*] You have stated that the derangement of a single wire in a lamp would cause an explosion?—Yes.

2759. If, instead of having a Davy lamp, he had had a candle, would there have been an explosion?—Undoubtedly, unless he had examined the mine; but if he had been going with a candle, he would have tried it here and there.

2760. *Chairman.*] Is it not the fireman's business to try with the Davy lamp whether the fire ignites or not?—It is seldom they do so in the main air-passages.

2761. If you were an over-man or manager, would you keep a man to go into and examine the mine, who did not try whether there was fire in the main air-passages?—No, I should think he ought not to be kept there.

2762. Mr. *Stephenson.*] In what particular colliery did this take place?—It took place in one of the collieries near to Bolton.

2763. Mr. *Locke.*] How long ago?—I can hardly state exactly; it is a few years since.

2764. Mr. *Stephenson.*] You have stated, in the course of your evidence, that there has been a great change in the management of collieries in Lancashire, since the appointment of inspectors; and you also added, that at the time when the inspectors were appointed, a great stir was made among the proprietors, and that they used the expression "We must now get things into better order, for these men are coming down." Can you name any one who said that?—Yes, I can name several; but it is not necessary to do so.

2765. You heard them yourself?—Some; the underlookers told me what instructions had been given to them; and I know that some of the masters are now getting boys and young men educated; and I know one master in particular,

lar, who has two or three boys who go along with the overlooker; so that they are being brought up to the business.

2766. Mr. *Locke.*] In the mines?—Yes; and all that has been occasioned by the present inspection being appointed.

2767. Mr. *Stephenson.*] You have also stated, that the responsibility sits very lightly upon the proprietors of collieries?—Yes, it does.

2768. When any serious accident occurs, are you not aware that the expense is very great to the proprietors?—It is very great, I believe; but, however, a man's life is more valuable than all the expense that they are put to.

2769. Would not the fact of a proprietor feeling that he had the lives of so many men in his hands induce him to be very careful?—We fancy it ought to do so; but in many cases it does not do so.

2770. Mr. *Locke.*] Then, in point of fact, the proprietor does not look to his own interest?—That is my opinion.

2771. Mr. *Cobbett.*] Has there been a difference, in that respect, ever since the inspector was appointed?—There has been considerably more care, but not so much as there ought to be. There is a considerable improvement for the better.

2772. Are the miners themselves satisfied of the fact which you have just stated?—They are.

2773. Are they satisfied that there has been greater caution since the inspector was appointed?—Yes.

2774. With reference to your own district, are there many mines which have but one shaft?—There is only one shaft in Mostyn Colliery.

2775. Mr. *Mostyn.*] Which colliery is that?—A colliery near Manchester.

2776. *Chairman.*] Upon looking at the returns, it is found that many accidents arise from falls of roofs and sides; in your district, is it usual for the collier to support his own roof, or are there men to do it, as there are in the Northumberland district?—Both plans are practised.

2777. Which plan is found to be the most efficacious?—The men setting their own props, and, as a matter of course, being paid for it. If the masters set the props, they take so much off each man. We generally had threepence a dozen in Yorkshire for propping; and it was considered better, and the men preferred to be paid for setting their own props; they considered that their lives were much safer.

2778. In general, in your district is sufficient timber furnished to the men by the proprietors of mines?—Yes, at the great majority of the collieries; but at some collieries there is not.

2779. In all the best managed collieries a sufficient quantity of timber is furnished to the men by the proprietors?—Yes; generally speaking it is the case, but there are exceptions.

2780. Do you think that the inspector should have the power of seeing that sufficient timber was furnished to the men?—I think that should be one of his duties.

2781. Did you hear the evidence which was given by Mr. Jude as to accidents in shafts?—Yes.

2782. Are you much liable in your district to accidents in shafts?—There have been several.

2783. Have all your shafts guides in them?—Not all, but principally.

2784. Do they go at a great speed?—We are not much troubled with great speeds in Lancashire, except at some few collieries.

2785. In point of fact, do you see anything defective in the general state of the shafts in your district, or do the workmen complain that they are defective?—I have often heard complaints of that kind.

2786. What do they complain of?—About the shafts not being properly walled. In many places they sink a shaft, and brick it at the top until they get to a solid foundation, and then they never put in any sheeting-board or anything, unless it is a mine which will not stand, until they get it to the bottom; in many cases they think that they are all right, if they can only reach the bottom.

2787. Is there any other complaint, except of the insecurity of the shaft itself?—We think that the enginemen ought to undergo some examination, and that they ought to be men who are qualified, and are really careful and cautious

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men, to wind men up and down collieries. Several men have been killed, as consider, through the negligence of the engine-tenters.

2788. Is it not the practice of the owners of collieries in your district to employ proper men to wind the men up and down the shafts?—They imagine they are proper men, but sometimes it turns out that they are not proper men.

2789. If a coalowner discovered that they were not proper men, would he not immediately dismiss them?—I cannot speak to that.

2790. Have you seen for any length of time, at any particular colliery, a man who was an improper man to be employed to wind men up and down shafts?—The men have often complained to me about young persons being employed, and that they did not feel that their lives were safe in their hands.

2791. Having received that complaint, what steps would you take?—We have no power of taking any steps, and the inspector has no power at the present time.

2792. Would you not report that to the inspector?—I do not know that I have had complaints about that since he was appointed; but there have been persons killed in Lancashire from the negligence of the engine-tenters.

2793. Since the inspectors have been appointed, what complaints have you received from the men?—As regards the engine-tenters, I have not received any complaint.

2794. You have only received complaints of the insecurity of the shafts themselves?—No; but still they are very desirous that the engine-tenters should undergo some examination. There have been many instances of men who were colliers, when they had done their work in the evening, going to an engineer and giving him a trifle to learn them to tent an engine; and in six months they would know how to handle an engine very nicely; and if they had a friend at court, they would be put to the winding engine.

2795. If accidents occur to the rope or machinery, is not the owner put to great expense?—Sometimes; if the guides are in good condition, a full tub may fall through to the bottom, without doing much damage.

2796. Do you think it is one of the duties of an inspector to see that proper engine-men are appointed, and also that the pits are walled, and in a safe condition?—Yes.

2797. Is it the custom in your district to let a man down while a full waggon of coal is going up the pit?—Yes, generally.

2798. Do you think that is safe?—No; it ought to be abolished.

2799. You think that ought to be prohibited by legislation?—Yes, under all circumstances.

2800. Mr. *Locke.*] Do you recollect any instance of death arising from stones falling out of the side of a pit?—Yes.

2801. Where?—I recollect a man being killed at Ardsley, near Wakefield.

2802. From a stone falling from the side of a pit?—Yes; his name was Taylor.

2803. What was he?—He was a hanger-on.

2804. Do you know of any accidents which have arisen in Lancashire?—Not where anybody has been killed, but I have known several men to be wounded.

2805. You were understood to state in an early part of your examination, that there were not many accidents of that kind?—There may be accidents, and yet not fatal.

2806. The question is not confined to fatal accidents, but it applies to accidents where men have been struck by stones falling; can you name any others?—I know that a man not long ago had his hand on a tub, and a piece fell down and disabled his hand.

2807. Was that a stone from the side?—Yes.

2808. It did not come from the top?—No, it came from the side; many of the sides of the shafts are very bad.

2809. Do you recollect in what pit that happened?—I cannot think of the name just now; I have known of several instances of people falling down ladders as well.

2810. You recollect one case where a man was killed at Ardsley, and another case of a man having his hand hurt by the fall of a stone?—Yes.

2811. And you know of other cases, but you cannot mention them?—Yes; the man had his second finger split in two.

2812. *Chairman.*]

2812. *Chairman.*] Are you aware, that by Act of Parliament boys are not allowed to wind men up and down pits?—I am aware of that; and I think the age out to be extended.

2813. What is the present age?—Fifteen years; I think that no person ought to be permitted to wind up and down shafts, who is under 18 years of age.

2814. Mr. *Stephenson.*] Do you think that inspectors ought to have the power of determining whether a sufficient quantity of timbering was used in collieries?—I do indeed.

2815. Does your answer refer to permanent timbering, or to temporary timbering?—It refers to all kinds of timbering; but more especially to temporary timbering.

2816. Does not the temporary timbering vary from time to time?—Yes.

2817. How is the inspector therefore, unless he is constantly in the mine, to give an opinion about the sufficiency or insufficiency?—When he does go in, he can give an opinion upon it.

2818. Do you think that inspectors when they are there, ought to have the power of condemning the existing timbering, and of ordering it to be replaced by sufficient timbering?—That is not exactly what I mean.

2819. Do you think it is possible, unless an inspector were there from day to day, that he could be of any real use as an inspector of the timbering?—If an inspector goes round the place, he will very easily see whether the men have sufficient timber set in their places, and whether they have timber laid by them, ready; and when he gets to the top of the pit, he would just go to the place where the timber for props was kept, and he would observe whether there was a proper supply of timber or not.

2820. *Chairman.*] Is it your opinion that if shafts were walled, such accidents as you have described would not occur?—They could not occur.

2821. Do you think it should be compulsory on the owner of a mine to wall the shafts?—Unless it was very good rock, which would not give way to the moisture of the pit or the heat of the pit.

2822. Mr. *H. Vivian.*] Do you include the walling of the pit in the 1,500*l.*, which you have stated as the cost of a second shaft?—Yes, on the average; because in many pits where there is rock, they would not be required; I do not mean to wall them from top to bottom.

2823. *Chairman.*] Do you think it should be in the power of an inspector to order pits to be walled, if necessary?—Yes.

2824. Are the men generally satisfied with the system of inquests, as they are at present conducted?—They are very much dissatisfied.

2825. Have they petitioned against them?—Yes; the principal objection of the men to the present system of holding coroners' inquests, is that the coroners are generally either doctors or lawyers, or persons who know nothing at all about the management of collieries; neither do they understand the technical words and terms which are made use of by the witnesses when they are giving their evidence; and they cannot comprehend what the witnesses are talking about.

2826. Are not the inspectors generally present?—The inspectors cannot always be present; they are sometimes present in urgent cases, and they are of great service.

2827. When they are present, do not the coroners generally pay great attention to what the inspectors tell them?—Sometimes.

2828. Have you known an instance of the contrary?—I have not known them to show any disrespect, but I have seen instances where I fancied they have not been particularly anxious that the inspectors should be very forward in putting questions.

2829. Have you ever been upon a jury at an inquest?—Yes, I have been at several inquests as a juryman; and I have also been at a great number to watch the proceedings on behalf of friends of the deceased.

2830. Mr. Jude stated that the objections of men in his district was, that persons connected with the mines, such as a master-blacksmith, a master-mason, and persons of that kind, were on the juries; and that the workmen thought they had a bias in favour of the coal proprietors, and did not perform their duty efficiently?—We have the same objection.

2831. Provided the jury were selected from men who were independent of influences of that kind, would the same objection exist?—No.

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2832. Do you think that the law as it at present stands, which only enables a jury to return a verdict either of accidental death or manslaughter, is defective? —It is very defective.

2833. In what does its defect consist?—The verdict must either be accidental death or manslaughter, as the law is at present; and juries generally have a great aversion to finding a verdict of manslaughter. Many of the juries at the present time, supposing it is an agricultural district, are farmers and others who pay rates; and if they send a man to the assizes, they have not the least doubt but that he will be acquitted, and that it will be the means of entailing on the county a great expense, a portion of which they have to bear; and it is constantly said, "What is the use of sending a man to the assizes to be acquitted, and for us to get a blowing up from the judge for so doing?"

2834. Are the Committee to understand that you have attended coroners' inquests in your official capacity?—Yes, and as a juryman also.

2835. Mr. *Locke.*] In the petition to which you have alluded, the objection which is stated, is not so much to the informality of the verdict as to the non-qualification of the persons who compose the jury; are you of opinion that the juries are ill composed?—Yes.

2836. You think that farmers, and petty tradesmen and others, are totally ignorant of the practical working of coal mines?—Yes.

2837. Do you think that the jury should be composed of persons who are practically conversant with coal mines?—Yes.

2838. How would you compose a jury to try a question of the kind?—I would have as a special coroner for all colliery accidents, a man who had been brought up in the mines, who had served his apprenticeship to a viewer or colliery manager, and who had received the very best education, and was a responsible man.

2839. Do you think that a Government inspector would be a proper person to be coroner?—I would not say a Government inspector, but a man of similar standing in society. I think that a Government inspector, so long as he held the inspectorship, as he might be a witness, should not be a judge.

2840. Do you think that a knowledge of practical mining is essential to the position of coroner?—I think that the one we have in Lancashire is the very sort of man who would do for the office, Mr. Dickinson; I think a man of his standing ought to be at the head of those inquests.

2841. *Chairman.*] Do you mean Mr. Dickinson the inspector?—Yes; but so long as they remain inspectors I would not recommend them.

2842. Would it not be necessary for him to have some knowledge of the law?—I think the law would be plain and simple, and that he would not have any doubt about it.

2843. However plain and simple, would it not be necessary for him to have a perfect knowledge of the state of the law?—He could devote some attention to that subject.

2844. Mr. *Locke.*] Do you think that if he had a knowledge of mining, he would be a great deal more useful?—A great deal. We have had too much law; we now want some justice.

2845. Mr. *Cobbett.*] You stated that you would have an inspector appointed as a coroner?—Men of similar qualifications.

2846. Mr. *Locke.*] Are you aware that all inspectors are not practical miners? —I am not aware of that fact. I have heard something about one inspector not being a practical miner, but as regards the truth of it, I have no certainty

2847. At all events, whether an inspector was a practical miner or not, you would insist that men who held the position of coroners should be practical miners?—Yes; I believe that all the inspectors, with the exception of one, are practical miners.

2848. Mr. *Cobbett.*] Are you aware that usually, at the present time, a coroner is elected by freeholders?—Yes.

2849. Would you have the coroner for the coal mines elected by freeholders, or would you have him appointed by the Government?—I would have him appointed by the Government.

2850. Would you dispense with the jury altogether?—No; I would have one portion of the jury composed of persons practically acquainted with mines, and the other portion of independent parties.

2851. Then,

2851. Then, in point of fact, you would alter the present mode of summoning the jury?—Yes.

2852. Is the jury at present summoned by the constable of the parish?—Yes.

2853. Are the jury taken from one parish, or from a number of parishes?—The general rule is with us, that supposing an accident occurs in our township, four gentlemen are summoned from each of the neighbouring townships on each side of us.

2854. Then hereafter would you have the jury summoned from the mines themselves, and from persons who were otherwise engaged?—Half the jury should be miners.

2855. Would you have any of the jury summoned out of the very mine in which the accident took place?—No.

2856. Do not you think that if you summoned persons from neighbouring mines, it is possible there might be some influence exercised over them by viewers or overlookers, such as has been stated with regard to accidents?—It is quite possible; but I do not think it would often happen.

2857. Do you think that the coroner should be a person acquainted with mining, and that half the jury should be acquainted with mining?—Yes.

2858. Do you propose to give that court the power to assess damages?—Yes.

2859. You propose to extend the power of the coroner to award damages in cases of accidents?—Yes, through gross neglect.

2860. Not merely to find whether the death arose from accident or from culpable negligence, and there stop, but to find what damage should be awarded to the survivors?—Yes, in case of death.

2861. Would you repeal the present law, by which the survivors can bring an action and recover damages, before one of the judges of the superior courts at Nisi Prius?—I think it ought to be enacted that the inspectors shall have the power of instituting proceedings for the recovery of damages in the case you are speaking of.

2862. Would you give them the power to institute the proceeding before a coroner which you propose they shall have the power to institute in one of the courts of law?—I should prefer the coroner's jury having the power of assessing damages, in addition to the present law.

2863. *Chairman.*] Is it your opinion that the magistrates or the inspectors should have the power of levying fines upon the owners of colleries who fail to perform their duty?—I think the magistrates ought to have the power.

2864. Do you think it would be better that the power should be given to the magistrates, or to the Secretary of State only?—I think it ought to be given to the magistrates. I do not see how the Secretary of State could be a judge upon the matter, because the master would have no chance of being heard.

2865. At present, is there a power to prosecute workmen who uncover their lamps in dangerous situations, or who commit any other reckless act?—Yes.

2866. Is it often the case that workmen are reckless?—There are a great number who are reckless, but they are persons who have been introduced into the mines; they are not persons who have been brought up to mining under the tuition of their father or relatives, or persons who have generally been taught the responsibility; they are generally persons who have been introduced into the mines as other kinds of labourers.

2867. If a man was found committing a reckless act, so that he endangered the lives of his fellow-workmen, would the workmen object to work with him?—Many of the men would complain of him.

2868. To whom would they complain?—They would complain to the manager.

2869. Have you known instances of such complaints being made?—Not specially to the manager; but I have often heard them talking among themselves that such a man had taken his lamp-top off.

2870. Did the men at the same time state that they had made complaints to the overman?—No.

2871. Is it your opinion, that provided such a complaint were made to the overman, the overman would take notice of it, and immediately send the man out of the pit?—I believe he would.

2872. Do you think it is desirable that there should be a specific enactment with reference to the carelessness of workmen?—I think the law is severe enough a present.

2873. Mr. *H. Vivian.*] Is the law sufficiently special at present?—If it can be

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be proved that a man has been guilty of the act, he is generally committed. I am not aware that they have much difficulty at the present time. There was considerable difficulty a few years ago; but the decisions have become very general, although the law is not very pointed upon it.

2874. Would not a material effect be produced on the men if there were a specific enactment against that description of carelessness?—Yes; supposing that the present law, which is rather doubtful, were defined, I think that the present law is quite sufficient.

2875. You mean that where the penalty is inflicted it is sufficient?—Yes.

2876. But that the law is not perhaps sufficiently definite?—Yes.

2877. Mr. *Locke.*] Are you well acquainted with the Lancashire and Cheshire mines?—I generally go amongst them, but I am not acquainted with their interior.

2878. What is your opinion of the qualification of the managers of the various collieries in Lancashire and Cheshire?—Very low, generally.

2879. Do you include Yorkshire?—Yes.

2880. Then you think that in Lancashire, Yorkshire, and Cheshire the qualification of the superintendents of mines is generally very low?—It is very low indeed, generally.

2881. Do you find a want of education among the superintendents, or do you allude to any moral defect?—There are both to a great extent.

2882. What kind of education have these men received?—A great many of them have had no education at all, except going to a school to learn to read and write, and cast a little, so that they can handle a pen nimbly and make a few figures, and work out a sum middling straight; but they have no really useful knowledge for mining purposes.

2883. Then those persons who have been so taught at school have no practical experience in mines before their appointment as managers?—Generally not; there are exceptions, but they are few and far between.

2884. Do those few cases of exception come up to your notion of the proper qualifications of a superintendent?—No.

2885. In your opinion, what qualification should an inspector or a superintendent of a mine possess?—I think that a manager of a mine ought to serve his apprenticeship, as they do in the North of England. I think that no man ought to be entrusted with the charge of a mine unless he has worked practically in a mine, and received a first-rate education, or served an apprenticeship to practical mining.

2886. Supposing that a man had been educated theoretically at a high-class school or college, and possessed all the theoretical information which could qualify him for accurately judging of any question relating to mining, would you admit him to the management of a mine, unless he had had some practical experience of a mine?—No.

2887. Then are you of opinion that theoretical education must always be coupled with a practical knowledge of the mode of working a mine, as well as of the principles of ventilation?—Yes.

2888. Is it your opinion that a man who has had a good thorough practical education, or rather experience in a mine, is sufficiently qualified, without having had a superior education, to manage a colliery?—No; I would sooner trust the practical man than the theoretical man; but I would rather have both.

2889. You have stated that you would prefer a workman who had some practical knowledge in the management of collieries?—Yes.

2890. Would you therefore make it imperative upon every person who was entrusted with a mine that he should have served an apprenticeship, or have obtained some practical knowledge in a proper and legitimate way of the working of a mine before he was entrusted with it?—The general notion is, that he ought either to have served seven years' apprenticeship, or to have held some inferior office, or worked in a mine in some way, at least 10 years.

2891. Are you now speaking of a person who is to take the charge of a mine?—Yes; the head manager.

2892. In some cases, where a man had been serving as an overman, or an underground steward, if he had long experience, do you think that he might be qualified to take a higher situation if he had been 10 years in the pit?—Yes.

2893. Then you are turning your attention to the qualifications for mining superintendence

superintendence by a practical man, rather than to high scholastic attainments?—Yes; but we would, as I say, rather have an educated manager and a practical manager as well. Supposing we must choose between the theoretical manager and the practical manager, we would select the practical manager.

2894. *Chairman.*] If a man in the course of his experience has educated himself, would he meet your views entirely?—Those are the very best of men.

2895. With regard to your answer as to the overmen in your district not being the right sort of men, are there not overmen in your district who are as good as the overmen in any part of England?—Yes; I said there were exceptions.

2896. In your district are schools general?—They are not.

2897. Are there not schools attached to a proportion of the collieries in your district?—Some of the largest collieries have no schools. I am not aware that Messrs. Knowles, who employ something like 1,500 men, have any school at all of their own building.

2898. You have heard Mr. Jude state that, provided the men had some share in the appointment of the schoolmaster, and a control over the schools, they would have no objection to a rate being made compulsory by Act of Parliament, to which they should contribute a certain amount of their earnings towards the support of a school; do you agree with that statement?—I believe that some would object to it, but that the greater part would approve of it.

2899. In your opinion, would that be a beneficial enactment?—I believe it would; I highly approve of it.

2900. Do you think that educating the colliers would make them less reckless, and more observant of danger?—I do.

2901. Do you consider that educating them would not only increase their moral culture, but be a means of preventing accidents?—I believe it would have a great tendency to it.

2902. With regard to funds; are they pretty general in your district?—We have Odd Fellows' and Foresters' Societies; but not much else.

2903. Did you hear Mr. Henderson's statement with regard to a national fund being raised?—Yes; but I hardly comprehend what he meant; because it would be rather difficult to manage a national fund.

2904. He stated that he would not have contributions from the Government, but that he meant a fund to which the whole of the colliers should contribute a certain amount in the pound from their earnings, which should be exclusively devoted to accidents, and the support of widows and orphan children; do you think that such a plan is practicable?—I believe that the miners of Lancashire and Cheshire would object to it.

2905. On what principle?—They appear to have a great notion of self-control.

2906. Supposing a deputation were appointed to manage the funds, do you think their objection would be removed?—They have no notion of money going out of their own county.

2907. Provided the fund was confined to their own district, do you think they would agree to it?—I think they would. Every fortnight they have meetings, and each colliery sends a deputation; of course they do not always send the same deputation; and they would have a perfect control over it in that case, and perhaps they would not raise objections to it. I am not advocating it; and anything beyond that, I am perfectly satisfied they would object to.

2908. Is there anything else you wish to state?—I think that if it is necessary to use safety-lamps, blasting ought to be prohibited.

2909. Does your answer apply to the use of tobacco pipes, under the same circumstances?—Yes.

2910. Mr. *Cayley.*] Who do you think should appoint the special coroner?—The Government.

2911. *Chairman.*] Are the workmen anxious for the Report of the Committee of last year to be carried out?—Generally, with very slight exceptions.

2912. Do you think they are satisfied with the attention Parliament is paying to the subject?—They are very thankful to the Legislature for the attention they have paid to the subject; but they are frightened at the Committee's being appointed, apparently for the discussion of the jet and the furnace.

2913. And they hope they will not be sacrificed, in the contest between the steam-jet

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steam-jet and the furnace?—Aye; they do not want to be sacrificed between the steam-jet and the furnace.

2914. Mr. *Cayley.*] Have you any notion that Committees are sometimes appointed with a view to delay legislation?—I am not aware of it.

2915. *Chairman.*] Do you think that the working men have the slightest idea that this Committee has been appointed with a view of delaying legislation?—We have bits of notions about it; because they say, "We have had inquiry enough, and sufficient has been said, and we all know that mines can be ventilated; the jet is good, and the furnace is good, either of them will do; we do not care which it is, only let us have air; we do not see that there is any further need of inquiry, because while they are inquiring we are being sacrificed."

2916. Mr. *Locke.*] You have stated that some change has taken place for the better?—Yes.

2917. Do not you think that a continued discussion would be rather useful in acting on the mining proprietors, to keep them a little up to the mark?—It was the Act of Parliament which made them attentive, and not the discussion.

2918. Do you think that Acts of Parliament would be passed, without preliminary discussion?—There has been discussion on this subject. In 1835 there was a Select Committee, and again in 1849, and again last year.

2919. Mr. *H. Vivian.*] Are you aware that the Act of Parliament arose out of the Committee of 1849?—Yes.

2920. That was a Committee of the House of Lords?—Yes.

2921. *Chairman.*] Are you aware how long the Committee sat last year?—No; I think about a month.

2922. Mr. *Locke.*] You ask for some amendment in the present law?—Yes.

2923. You mean that the amendment should take place after a proper inquiry had been instituted?—Yes, if there has not been sufficient inquiry; but we think there has been inquiry enough.

2924. *Chairman.*] You say that the Committee of last year sat a month; supposing that only five days' evidence were taken, do you think that was enough?—The Report was very good.

2925. Have you read the evidence?—I have read most of it; I cannot say that I have read it all. The Report is very good.

2926. Is it your opinion, that this inquiry will do good?—I think it will.

2927. Mr. *Mostyn.*] Are you aware that the last Committee only sat five days?—I am not.

2928. *Chairman.*] You have stated that great good has been done by inspectors in the ventilation of mines. Since the inspection, have you found a visible improvement in the health of the working miners?—Yes; and not only do I observe an improvement in the appearance of the men, but each man's name is registered in a registry-book, with his contribution each fortnight; so that by comparing the collieries, I can see that there is a visible improvement.

2929. And you attribute that to the attention which the present inspector has paid to the ventilation of mines in his district?—I believe it has arisen entirely from the inspector being appointed.

2930. And you believe that the present inspector generally gives satisfaction, both to the men and the masters?—Yes.

2931. Mr. *Cayley.*] The Committee of 1852 gave satisfaction to the working miners, although no working miners were examined?—Yes.

2932. Mr. *Mostyn.*] Are the instructions of Mr. Dickinson usually attended to in your district?—They are.

2933. You know of no instance to the contrary?—None; and whenever I see him, he asks me if I know of any mine which is dangerous; he is always anxious to get information of dangerous mines.

2934. Is attention paid to his instructions by the proprietors of mines?—Yes, generally; but there are some cases where, unfortunately, they have not been attended to.

2935. Mr. *Cobbett.*] You attribute the better appearance of the working people to the circumstance of Mr. Dickinson's recommendations having been attended to?—I cannot say that; I attribute it to the Act of Parliament being passed, because if the Act of Parliament had not passed, and the inspectors had not been appointed, they would never have improved their ventilation.

2936. *Chairman.*]

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2936. *Chairman.*] Then, from the appointment of the inspectors, and the attention that the inspectors have paid, the ventilation has been improved?—Yes.

Mr. *William Gray*, called in; and Examined.

Mr. *W. Gray.*

2937. *Chairman.*] WHERE do you reside?—At Margam.

2938. Have you been long acquainted with the working of collieries?—All my life.

2939. Have you been a workman in collieries?—Yes.

2940. Did you begin early in life to work in collieries?—Yes.

2941. At what age did you go into a colliery?—About 10 years of age.

2942. What was your occupation?—Keeping a door.

2943. Did you then become a cutter?—Yes.

2944. Were you long employed in hewing coal?—Not long; I should think not longer than two years.

2945. Were you advanced?—Yes.

2946. What did you become?—A deputy.

2947. Your duties then were the superintending and standing of timber?—Yes; and bratticing.

2948. How long were you engaged in that occupation?—Not very long; perhaps a year, or a year and a half.

2949. Did you then become an overman?—No; I then followed the occupation of sinking.

2950. Did you sink many shafts?—Yes.

2951. In what districts?—Chiefly in the Monkwearmouth district, and Unsworth.

2952. Had you anything to do with sinking the Monkwearmouth pits?—Yes.

2953. How long did you continue a sinker?—I should think that I was employed four or five years as a regular working man at sinking; the last four or five years of my servitude in sinking was as a master sinker.

2954. Did you continue to rise until you became an overman?—Yes; the last colliery was Unsworth colliery, where I had any connexion with sinking in the north of England; and I became overman of a colliery after the pits were sunk.

2955. Were you the overman who was engaged in opening the Unsworth colliery?—Yes; I sunk it, and opened it out.

2956. How long did you remain overman of Unsworth colliery?—About a year and a half.

2957. Where did you go?—I was engaged by Mr. Vivian, through the recommendation of Mr. Elliott, my former master.

2958. Have you been ever since with Mr. Vivian?—Yes.

2959. How long have you been with Mr. Vivian?—Nearly five years.

5960. Have you opened collieries since you have been with Mr. Vivian?—The colliery I came to was about 30 fathom standing when I came.

2961. Did you put a pit 30 fathoms down?—Yes; my first duty was to sink two pits down to the coal and working; and I have since had the chief management of that colliery.

2962. In point of fact, you have been all your life engaged in collieries?—Yes.

2963. Can you state the extent of working that you now superintend?—From one of the collieries that I manage there are about 100,000 tons raised annually.

2964. Can you describe the winnings of those pits?—Yes; they are sunk on a marsh, or a sea deposit; and no strata are met with, nothing but peat, and shells, and gravel, and stone, until we get down about 70 feet, and then we get the coal formations. We then generally sink until we find a place to form foundations for tubbing. Wales has a peculiar lime which stands water.

2965. Do you mean the lias limestone?—Yes.

2966. Are you much troubled with water in that district?—There is a very large quantity of water to contend with till after the tubbing is in.

2967. Have you directed your attention very much to ventilation?—Very much indeed.

2968. Have you directed your attention to any particular method of ventila-

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tion, or to ventilation generally?—Not to any particular method of ventilation, but to ventilation generally.

2969. Have you ever used the steam-jet?—Yes.

2970. And also the furnace?—Yes.

2971. Have you ever made any experiments with regard to the steam-jet?—Yes.

2972. Under what circumstances have you used the steam-jet?—The nearest road we have got between our pits is 500 yards, and it is a very awkward thing to form a holing between two pits which are sunk a great distance from each other; and some easy mode of ventilation has to be contrived in some way, until a perfect one is got. In the first pit we sunk we put a brattice, and ventilated it on the high pressure system through the brattice.

2973. As a temporary remedy?—Yes.

2974. Did you find the steam-jet answer the purpose for which you adopted it?—Yes.

2975. Did you continue to use it after the pit was worn out?—No.

2976. Why did you abandon it?—I should not like to work it on a large scale.

2977. Why not?—I think it is a very slippy practice of ventilation.

2978. What do you mean by a "slippy practice?"—Easily slipped out of management altogether; it is not good to keep hold of.

2979. How?—So many things will go wrong about it.

2980. When you applied the steam-jet, had you the fires and the boilers which raised the steam at the bottom of the pit or the top?—The top.

2981. You took the pipes to the bottom?—No.

2982. How did you proceed?—I will read some of the experiments which I made. "The Morfa colliery was worked in 1849 with only one pit, divided by three-inch plank brattice into winding-shaft on one side and pumping-shaft on the other side. Winding-shaft was the down-cast of 50 feet area; pumping-shaft the up-cast of 25 feet area. Making an allowance for pumps, rods, beams, &c., the up-cast would not exceed 18 feet area. The ventilation was worked by high pressure steam, a culvert leading from the up-cast to a stack 60 feet high, with 16 feet area at the top, with the jet-pipes 8 feet from the bottom of the stack; 75 jets of $\frac{1}{8}$ inch square, worked by two Cornish boilers, 30 feet long by 6 feet diameter, burning three tons of coal per 24 hours; steam worked up 50 lbs. per inch pressure; and, according to Biram's anemometer, measured—

On December 19, 1849, 11,600 feet per minute.
On December 30, 1849, 13,104 ,,
On February 17, 1850, 14,300 ,,

Averaging about 13,000 feet per minute. This plan of applying the steam was abandoned. To apply the blast-pipes, a chamber was built 10 feet high, with sufficient area for 35 blast-pipes of 10 feet long, 5 inches diameter, the bottom part coned out to 10 inches diameter at the bottom, or receiving end, 35 jet tubes, 12 inches long, screwed perpendicular into the horizontal branch pipe, and each jet reaching 12 inches up the blast-pipes, and about 2 inches above the cone, or 2 inches into the parallel part of the blast-pipe; 18 of these jet-tubes were $\frac{3}{16}$ inch area, and 17 tubes $\frac{1}{8}$ inch area, worked from the same boilers, at 50 lbs. pressure per square inch, and burning three tons of coal per 24 hours, and measuring, according to Biram's anemometer—

On the 20th June 1850, 19,000 feet per minute.
On the 1st July 1850, 18,000 ,,
On the 14th Sept. 1850, 21,300 ,,

Averaging about 19,000 feet per minute. This gave us an increase of 6,000 feet per minute over the jets merely going into the stack. The air was split into four divisions; average length of air-course 1,300 yards, of about 36 feet area each, which is about 4,077 feet of air per minute for one pound of coal consumed.

2983. Mr. *H. Vivian.*] Was the general result of the use of the blast-pipe system that you obtained an increased ventilation?—Yes; it increased on an average from 13,000 feet per minute to 19,000 feet per minute with the same boilers.

2984. *Chairman.*] Was that with the steam-jet alone, without any adjunct from

from rarefaction of any kind?—Yes, and at the top of the pit; and the jets were in the up-cast pit, covered down by three-inch plank doors.

2985. Mr. *H. Vivian.*] Was the utmost amount of ventilation you could obtain by the system you have described, from two Cornish boilers issuing into blast-pipes, similar to the blast-pipes of a locomotive engine at the top of the pit, 20,000 cubic feet per minute?—Yes; but, under better circumstances, we could have got more from the same boiler power.

2986. *Chairman.*] State the best circumstances, and the greatest power which you have obtained in your experiments?—We got a difference of from 13,000 to 19,000 cubic feet per minute.

2987. Are the Committee to understand that 19,000 cubic feet per minute is the greatest quantity you have obtained under the most beneficial circumstances?—We acted under very awkward circumstances.

2988. Acting under the best method that you have adopted, what is the greatest amount of ventilation you obtained?—I had not the power of adapting it to a better method, for the size of my pit confined me.

2989. You have stated, that with the means which were within your reach you raised the ventilation from 13,000 to 19,000 cubic feet per minute?—Yes.

2990. Mr. *H. Vivian.*] Have you since abandoned the steam-jet system of ventilation?—Yes.

2991. On what account?—Its being so liable to get out of order.

2992. When the two pits were connected, did you erect a furnace in the up-cast shaft?—Yes.

2993. What results did you obtain from that furnace?—We now get about 70,000 cubic feet of air per minute.

2994. By what consumption of coal?—Two tons and a half per 24 hours.

2995. *Chairman.*] That is a larger shaft than the one you have been speaking of?—Very much.

2996. Did you ever apply the steam-jet to the same shaft?—No.

2997. Then you have not made any comparison between the power of the furnace, and the power of the steam-jet in that shaft?—No.

2998. Mr. *H. Vivian.*] Was it a temporary arrangement?—Yes, until we got the other pit sunk.

2999. *Chairman.*] Is this a very fiery colliery?—Yes.

3000. Is it as fiery at the collieries in the north of England?—Yes.

3001. Is it necessary to pay great attention to the size of the air-ways?—Yes.

3002. Do you adopt the Newcastle mode of splitting the air?—Yes, to a great extent.

3003. How many men have you working in the colliery?—We have about 220 lights going; and I suppose 180 of them are men, and the others are boys.

3004. Do you make your splits with reference to the number of men in each department?—Yes; that must be attended to, to a certain extent.

3005. At the same time, in your opinion, is it not absolutely necessary that every man should breathe a certain portion of fresh air, which has not been impregnated by gas or by the breath of other men?—A pair of exploring drifts might be going into solid coal with only two men, and require more air to keep them safe than another district with 20 men.

3006. In your opinion, is it essential that each man should have a certain amount of air which has not been breathed by other men?—Yes, that is what we attend to.

3007. Do you conceive that any colliery can be judiciously carried on, however great may be the amount of ventilation, or whether the ventilation is raised by steam-jet or furnace, or whatever quantity of air may be taken down the shaft, unless particular care is paid to the distribution of the air, that each part of the colliery may have a sufficient quantity of fresh air?—That is one of the most important points.

3008. Have you paid great attention to that?—Yes; I have made it my chief study.

3009. You have stated, that in your colliery you have as much fire-damp to contend with as there is in the most fiery collieries in Northumberland; have you ever had an accident in your mine?—Yes.

3010. Of what nature?—We had an accident from fire-damp three years ago.

3011. How many men were burnt?—None were burnt to death at the time, but seven died afterwards.

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3012. What was the cause of the accident?—An explosion of fire-damp.

3013. Was it investigated by the inspector?—Yes.

3014. Did he make a report upon it?—Yes.

3015. What did he state to be the immediate cause of the explosion?—That it was not safe to work so explosive a mine with open lights; it was a new vein of coal, and we had no extent of working open.

3016. Mr. *H. Vivian.*] Did the accident happen very shortly after the mine was first opened?—Yes.

3017. *Chairman.*] In consequence of his report did you report to your employers his opinion, and did they act upon his opinion?—Yes.

3018. Since that time have lamps been used?—All the coal has been cut with safety-lamps ever since.

3019. Has any naked light been used at all?—Yes.

3020. Where?—We have appointed the district where the naked light goes up to, on the main road.

3021. Do the men invariably cut the coal and perform their work with safety-lamps?—Yes.

3022. Since the use of safety-lamps have you had any accident?—Not one.

3023. Have you had the inside of the lamps on fire?—Yes.

3024. What safety-lamps have you used?—The common Davy.

3025. Do the men ever complain of a want of light from the Davy lamp?—No.

3026. Do you think men are satisfied to work with the Davy lamp?—Quite so.

3027. Do you think they prefer it to a candle?—I do not think they like it better than a candle.

3028 Mr. *Mostyn.*] Do you prefer the Davy lamp to the Clanny lamp?—Yes, for the working men.

3029. *Chairman.*] Why?—I think the Clanny lamp is a dangerous lamp for any person except the officers.

3030. In consequence of the glass being liable to be broken by the water?—No; I have seen a glass split out of the side by its being badly annealed.

3031. Have you seen the lamp which has been invented by Dr. Glover?—Yes.

3032. What is your opinion of that lamp?—It is a double security to the other.

3033. Do you think that lamp would not give greater light, and afford as much security, as the Davy lamp?—I think there is quite enough light by the Davy lamp.

3034. Is it the practice in your pit, using (as you say you always do) the Davy lamp, to have one or two men to repair the lamps and to clean them, and fill them with oil?—Yes.

3035. You never allow the men to do that?—Never.

3036. Do you also have men under ground to keep the keys of these lamps?—Every deputy and overman has a key.

3037. Did you ever know an instance of a lamp being unlocked by a workman?—Yes.

3038. How did he manage to unlock the lamp?—We have had the keys taken out of the lamp-house.

3039. And you have had workmen working with the lamps unlocked?—Frequently.

3040. What do you do under those circumstances?—We fine the man as severely as we can.

3041. Do you ever get that reported to you by the other workmen?—Yes, it has been done.

3042. Do you think that workmen would at all times report to you if they found a man committing a dangerous act of that kind?—I think that generally they would.

3043. Have you ever endeavoured to obtain a summons against a man for opening his Davy lamp?—Yes; I have tried that.

3044. Did you fail?—Yes.

3045. On what ground did the magistrates refuse to grant you a summons?—They refused to grant a summons on the ground that the man had merely broken

broken the rules of the colliery, and that in their court they had nothing to do with the rules of our colliery; that we might make such rules and levy such fines as we pleased; and that unless the man had done anything to injure a person, we could not bring him up.

3046. Do you think it would be desirable to make it an offence against the law for a workman to take off the top of his lamp?—I think it would be a very good thing, and it would be very easily understood.

3047. Mr. *H. Vivian.*] Would it produce a great moral effect?—It would.

3048. Mr. *Fitzroy.*] By your own bye-laws, do you fine a man for taking off the top of his lamp?—Yes.

3049. Have you any difficulty in enforcing the fine?—I have never had any difficulty.

3050. Has it produced the result of checking the practice?—Some men who are working in the colliery have been fined 21 *s.* twice, for smoking tobacco in the colliery.

3051. Has the infliction of a fine had the effect of checking the practice of uncovering the light?—To a certain extent, but it has not done away with it entirely.

3052. To what extent can you fine by the regulations of your colliery?—Twenty-one shillings is our highest fine.

3053. Mr. *Cobbett.*] Do you stop it out of the wages?—Yes.

3054. Mr. *Fitzroy.*] Why do you imagine that if the fine was inflicted by a magistrate it would have a greater effect than if it was inflicted in pursuance of the regulations of your colliery?—I think it would act more upon the mind of a working man if he was brought before a bench of magistrates, and he felt that his name would probably appear in the press in the next week.

3055. You think that circumstance would have a greater moral effect than the infliction of a pecuniary fine by the owner of the colliery?—I think a very great deal.

3056. *Chairman.*] You have stated that you now altogether work with safety-lamps; can you state to the Committee whether you pay men more for working with safety-lamps than you paid them when they worked with candles?—We pay the same price per ton as we paid before.

3057. Can you state the cost of the safety-lamps?—Yes.

3058. Do you find the oil for the men?—We find all the oil, and all the lamps.

3059. Did you find the men candles before?—No; they found their own lights before.

3060. And now you find them the oil with the safety-lamps?—They pay so much per day for the lamps and oil; but we supply them with light cheaper than they could supply themselves.

3061. Can you give the Committee any idea of the difference in the expense?—I find that I can maintain 220 safety-lamps for 220 *l.* per annum.

3062. Including repairs, wear and tear, and everything?—Yes.

3063. What do you allow for wear and tear?—I have made it out thus:—

	£.	s.	d.
"1,050 gallons of oil, at an average of 2*s.* 10 *d.* per gallon -	148	5	–
60 new lamps, per annum, at 6 *s.* 3 *d.* - - - - -	18	15	–
70 lbs. of fine cotton, at 1 *s.* 4 *d.* per lb. - - - - -	4	13	4
Wire-gauze, wire for poles, solder, tools, &c. - - - -	10	–	–
Wages to oiling, trimming, and keeping the same in good repair, at 12 *s.* per week - - - - - - - - -	31	4	–
Locking lamps under ground; 300 days at 6 *d.* - - -	7	10	–
£.	220	7	4

"Cost of each light, per day, 0·80 *d.*"

3064. Have you compared that estimate with the cost of candles?—I have drawn out a comparative statement of the cost of burning candles daily.

3065. Mr. *H. Vivian.*] Have you contracted for a supply of candles?—Yes; I have been an overman, where I have supplied the colliery with candles.

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3066. *Chairman.*] Therefore you are able to arrive at an accurate estimate of the cost?—Yes.

	£.	s.	d.
"To maintain 220 lights per day: 180 workmen, averaging 10 hours per day, using six candles each, of 30 to the pound; 40 boys, averaging 12 hours per day, using seven candles each, of 30 to the pound, equal to 45⅓ per day, at 6 *d.* per pound; by allowing 300 working days per annum - - - - -	340	–	–
"Wages to one man for taking charge of these candles, and serving them out, at 12 *s.* per week - - - - - -	31	4	–
£.	371	4	–

"Cost of each light per day - - - 1·34 *d.*"

3067. In point of fact, is it 50 per cent. cheaper to work with safety-lamps than with candles?—Yes. It is a halfpenny per day cheaper to work with safety-lamps. The one costs about 1⅓ *d.*, and the other costs rather better than ¾ *d.*

3068. Have you read the Report of the Committee of 1852, with regard to safety-lamps?—Yes; I cannot bear the whole of it in mind.

3069. That Report states, that under particular circumstances the Davy lamp is not safe, and that the Committee do not recommend its use. In your experience, have you known any accident occur from the use of the Davy lamp?—Yes; I have known a lamp get damaged, and an explosion to take place.

3070. Suppose the lamps were kept in proper repair?—I never saw a perfect lamp explode.

3071. Do you think it would be proper to enforce by legislation the use of safety-lamps in fiery collieries?—Yes, I think it would be advisable.

3072. Mr. *H. Vivian.*] Would you lessen the ventilation because you used safety-lamps?—No.

3073. *Chairman.*] You would use the safety-lamp as an adjunct to ventilation?—Yes.

3074. How long have you been working with safety-lamps?—Three years.

3075. You have never had any explosion or accident since you used them?—No.

3076. Your workings have been carried on from day to day to a greater extent, and you have had more fire-damp to encounter, than you had when you were using the candles?—Very much.

3077. Do you ever find the lamp get red-hot?—No; we do not allow any person to work with his lamp on fire.

3078. Do you use brattices?—Yes.

3079. Do you pay particular attention to carrying the brattice up to the face of the shaft?—We could not work in a stall for a day without brattice, because the vein lies at an angle of 18 inches to the yard.

3080. Have you any printed regulations in your colliery?—Yes.

3081. Will you hand them in?—Yes.

[*The Witness delivered in the following Statement:*]

RULES and REGULATIONS to be observed by the Workmen employed at the Morfa Colliery.

More than six men are in no case to ride at one time, and the engineman is to lessen the speed of the engine to one half.

The firemen are to enter the colliery every morning at a sufficiently early hour to enable them to try each stall where a man is required to work, and having done so, to report to the overman the state of the colliery, before the arrival of the men. As an additional precaution, should they find any stall dangerous, they are required to fix a signal board, with the words "No person to enter this stall."

The cutter is required to see either the overman or fireman before proceeding to his work. Should the cutter at any time consider that his stall is in a dangerous state, he is at once to leave it, and report the same to the overman.

The onsetter must send all the men and boys up the pit before he leaves the pit bottom.

The bankman must not leave the top of the pit, until the onsetter has come to bank.

No

No cutter or trammer is allowed to use a safety-lamp, without its first being examined by the lamp inspector, and then locked, and again re-examined by the overman or fireman.

Should any accident happen to a lamp while in use, by which the oil may be spilt upon the gauze, or by which it might in any other way be rendered unsafe, it is immediately to be taken out to the station fixed upon by the overman, and not again used until after having been properly examined by the overman or fireman.

Any cutter, trammer, or workman, on the appearance of fire-damp, is to retreat to a pure atmosphere.

All persons to whom the safety-lamp is entrusted are strictly prohibited from interfering in any way whatever with the lamp, beyond the necessary trimming of the wick with the picker; and the lamp is not to be placed within three feet of the side of the goaf, and not nearer the face of the coal than five feet.

Should any cutter, trammer, or other person, when in charge of a safety-lamp, lose his light, he is to take it to the station fixed upon by the overman, to be re-lighted; and when re-lighted it is to be examined and locked by the fireman before being again used.

It is particularly requested that any person witnessing improper treatment of the safety-lamp will give immediate information to the overman in charge of the pit, in order that proper steps may be taken to guard the lives of the workmen employed in the mine.

Smoking is not allowed in any part of the mine, and persons found so offending will be liable to a fine of 10 *s.*, or be taken before a magistrate, and the fine to be paid to the informer.

No candle to be taken nearer to the pillar working than the station fixed upon by the overman; and any one found with a lighted candle within that distance will be fined 10 *s.*; the fine to be paid to the informer.

On no account is any person to keep a gun or dog of any kind.

No person is to have any description of gins, traps, or nets used for snaring game; and if found with any, he will be fined 15 *s.*

No one not connected with the colliery will be allowed to remain about it; and the timekeeper will be fined 2 *s.* 6 *d.* for each person so offending.

The workmen that are employed at the colliery are required to keep the direct road, and in nowise to trespass on the land by coming to, or going from their work; and if found so trespassing will be either discharged or fined.

3082. Do you prohibit smoking where safety-lamps are used?—Yes.

3083. Do you make any regulations with regard to the use of gunpowder?—Yes.

3084. Is the coal altogether hewn without gunpowder?—We use gunpowder.

3085. What are your regulations with regard to the use of gunpowder?—"To all that are working in the pits at the Morfa Colliery:—First, any person found smoking tobacco, or has in his possession pipes, tubes, cigars, or lucifer matches within these pits, will be fined one guinea. Second, all blast powder to be discharged by the overman or deputies. Third, any other person in the coal-working district of the colliery discharging blasting powder will be heavily fined." That is printed in large letters, both English and Welsh, at the lamp cabin.

3086. Mr. *H. Vivian.*] Have you found it almost impossible to prevent smoking?—One man has been fined twice for smoking.

3087. *Chairman.*] Before you employ the men, do you read the rules to them?—Yes.

3088. Do you employ them on condition that they submit to those rules?—Yes.

3089. Have the rules ever been disputed by the men, and have you ever been taken before a magistrate for fining a man?—Never; but I have often been threatened to be taken before a magistrate.

3090. Do you find that the generality of the men cheerfully submit to the infliction of a fine if they break any rule?—Yes.

3091. Do you think that the safety of your mine is very much enhanced by these regulations?—Yes, very much indeed; I think that we should not be able to go on unless we observed the rules.

3092. Are there any regulations with regard to lowering the men down the pit?—We confine ourselves to a certain number in going down and coming up.

3093. Do you limit the engineman to a certain speed?—Yes; he has a printed board in the engine-house.

3094. What is the ordinary speed at which you wind the men up and down?—We draw up coals at the rate of about 80 fathoms in half a minute.

3095. At what speed do you wind the men up?—In about three quarters of a minute.

3096. In winding up that pit have you had many accidents?—Only one.

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3097. How much coal is raised from that pit?—About 100,000 tons per annum.

3098. In the course of four years you have had only one accident in the pit?—Yes; and this was caused by a person disobeying the order of the onsetter at the bottom; the carriage was lifting from the bottom; there were six men in it, and he leaped into it, and was caught at the first beam, and his neck was broken.

3099. Do you ever let men down when a full carriage of coals is coming up?—Yes.

3100. Your carriages are so made that none of the coal is above the top of the carriage?—There is a very strong plank cover fitted to the top rim of the carriage, a three-inch oak plank; so that no coal can possibly fall through and injure the men. If a piece of the ground in the shaft was to fall, it would not at all injure a man on the inside, because he has got a three-inch plank cover over his head, and there are three bolts through that cover; so that if the plank were broken the bolts would prevent the man from being injured.

3101. You have never, in any case, had any accident from substances falling on the men?—None.

3102. Mr. *H. Vivian.*] Have you known substances fall on the cage?—I have known a castiron tram-plate to fall from the top of the pit to the bottom, and only smash the cover in such a way that if a person had been inside the carriage he would not have been hurt.

3103. *Chairman.*] Is your pit walled from top to bottom?—The up-cast is walled.

3104. Do the men come up the up-cast?—No, the down-cast; it is all finished with tubbing to the feeder, and after that with inch and a half plank.

3105. All the way down?—Yes.

3106. So that it is impossible for material to fall out and injure the men?—Yes.

3107. Is it your opinion that the inspector should have the power, in your particular district, to see that the pits are properly walled or made safe, and that he should be allowed to enforce proper regulations for winding the men up and down the pits?—I would not object to his having the power of getting the pits walled; but I think that the manager of the colliery ought to know, as well as any other person, how to get the men up and down the pit.

3108. On looking at the returns, it appears that nearly 300 lives are every year sacrificed by accidents in winding men up and down the pits. In your colliery, where these regulations are in force, you say that during four years you have only had one accident. Is it your opinion that considerable accidents arise in consequence of carelessness?—Yes; in the three particular collieries that I have been connected with during the last 11 or 12 years, I cannot bring to my memory more than one man being killed.

3109. Is it not your opinion that these accidents arose from carelessness?—Yes.

3110. If an inspector had the power to see that care was taken, and that proper rules were adopted, do you think it would affect the owners of mines, who do take care of the safety of their workmen, as you seem to have done in the pits with which you are connected?—No.

3111. Do you see any objection to giving the inspectors the power to see that the pits are properly walled or made safe, and also to give them power to enforce proper regulation, so as to ensure the safety of the men?—No.

3112. In your own district, is it the custom for each collier to set his own props?—Yes.

3113. Have you ever tried Mr. Fourdrinier's cage?—Yes.

3114. Do you work it now?—No.

3115. Did you ever work it?—Yes.

3116. How long did you work it?—I should think for a year.

3117. What is the reason you abandoned it?—It is subject to get out of order, and is more dangerous than valuable; it catches in the pit.

3118. Supposing it did catch in the pit, what would be the consequence?—Half a ton of rope would go down on the cage, and perhaps force the guides out. Mr. Fourdrinier's apparatus has only power to hold on the guides; and if the guides are forced away, all goes together.

3119. Have

3119. Have you seen White and Grant's apparatus?—Yes; I have seen a model of it.

3120. Would the same observation apply to that apparatus?—Yes.

3121. Have you had an accident in your pit, in consequence of the Fourdrinier apparatus catching?—Yes; I have known a catch hang ten fathoms off the bottom, and the rope all come on it.

3122. Without damage?—Without damage; because there was not a sufficient weight of rope to carry the whole concern away. If it had been in mid-pit, where a large quantity of rope might have been on it, the consequence would have been, that it would have forced it away.

3123. In your district is it the custom for the men to set their own props?—It is very much the custom for the men to set their own props.

3124. Have you deputies in your pit?—Yes; we are obliged to have them in our colliery, which is rather an exception to the general rule in Wales.

3125. Do you approve of the principle of having deputies?—Yes.

3126. State your reasons?—The deputies in our pit have the charge of putting in all brattices and brattice posts, and firing all the blasting powder, and they have little districts allotted to them, of which they have the superintendence under the overmen. That is their daily occupation, and they remain in the district; and if anything goes wrong with any of the brattices they are there to put them in order, and they have the overman to apply to, which they can always do in a quarter of an hour or twenty minutes, finding him in another part, for assistance.

3127. Have you had accidents from falls of roof in your pit?—Only one man has been killed from a fall of coal.

3128. To what do you attribute so small a number of accidents?—I think it may be attributed to the strict attention which has been paid, to having the roof of the pit properly timbered, and inducing every officer to feel a responsibility resting upon him in the work which he has to perform.

3129. Is it your opinion that if greater care were taken, the number of accidents from those causes would be greatly diminished?—Yes.

3130. Has the inspector ever visited your pits since you have been there?—Yes, several times.

3131. In your opinion does the system of inspection work well?—I like it very well.

3132. Does the present inspector, Mr. Mackworth, give great satisfaction in the district?—Yes; I have never heard any person state the contrary.

3133. Is there a general disposition in the district, as far as you are acquainted with it, to follow reasonable suggestions of the inspector?—Yes.

3134. How often has Mr. Mackworth visited your pit?—I cannot say exactly; I think half a dozen times. He came twice on purpose to try the natural brattice.

3135. Do you believe that there is such a thing as a natural brattice?—No, not in a colliery.

3136. Do you think that if the air-ways were kept sufficiently large, it would be possible there might be such a thing as a natural brattice?—I think that if they were shut off altogether, it would not take place.

3137. Supposing the air-ways were sufficiently large to fill the up-cast shaft with air, could a natural brattice by any possibility exist?—It would not have any chance, if there was not a furnace.

3138. Mr. *H. Vivian.*] Have you taken the temperature of the shaft at various parts?—Yes.

3139. Have you any figures showing the temperature of the shaft?—I took the temperature of ours on Friday night.

3140. Will you state the temperature?—I found that we had 68,500 feet of air per minute through the colliery, which was rarefied from 62 degrees, before going on to the furnace, to 163 degrees, 20 feet from the top of the up-cast pit. Three-fourths of the air was carried over the furnace, and one-fourth taken into the up-cast by a separate drift, generally called the dumb drift. The temperature of the air at the top of the furnace arch, before entering the shaft, was 230 degrees. The temperature at the middle shaft, 40 fathoms, was 195 degrees. The temperature at the top of the up-cast shaft was 163 degrees. The temperature at the bottom of the down-cast shaft was 58 degrees.

Mr. *W. Gray.*
4 July 1853.

3141. *Chairman.*] Do you think it is possible that a natural brattice could exist if you had plenty of air-ways?—No.

3142. With regard to the furnace paradox, is it your opinion that heating the shaft and heating the furnace to an enormous extent would not increase the ventilation?—It is sure to increase it.

3143. Then the more rarefied you can make the air, in your opinion, there must be an increased ventilation, if sufficient attention were paid to air-ways?—Yes.

3144. Did you ever hear the men complain of having too much air in a Colliery?—Not in the stalls. The men would have, perhaps, some difficulty in turning out with a light in the main roads. That would not be an inconvenience; it would merely be a little annoyance to put them in the dark; but the men would not find fault at all with it.

3145. You do not think there is any fear from having too much air in a colliery?—No; I think it is the right side to get wrong upon, at all events.

3146. Have you ever worked your colliery by long work?—Not the Mofar Colliery.

3147. Mr. *H. Vivian.*] Practically speaking, do you find that gas invariably rises from those portions of the colliery which have been worked?—Yes.

3148. Consequently is it your practice to keep the air current sweeping along the upper face of the workings?—Yes.

3149. In doing so, have you ever found that any accumulation of gas takes place in the goaf or former working?—As long as the air-way is maintained and kept open at the high part of the goaf, I have never seen any accumulation of gas in the goaf.

3150. You are in the habit of making a deduction of 1½*d.* per week from each man for school, the same for the surgeon, and the same for the sick fund?—Yes.

3151. Have you ever found the men object to that deduction being made?—No.

3152. Have they always expressed themselves well contented with it?—Yes.

3153. *Chairman.*] Is there anything else you wish to state to the Committee?—No.

Jovis, 7° die Julii, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Mostyn.
Mr. Ingham.	Mr. H. A. Bruce.
Mr. Baird.	Mr. Cobbett.
Mr. Cayley.	Mr. Locke.
Mr. Stephenson.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Mr. *Allan Tetlow*, called in; and Examined.

Mr. *A. Tetlow.*
7 July 1853.

3154. *Chairman.*] WHERE do you reside?—At Hurst Carrs, near Ashton-under-Lyne.

3155. Have you been deputed by the Miners' Association to give evidence before this Committee?—Yes.

3156. What is your branch of the Miners' Association?—In Lancashire.

3157. What place?—The different towns and districts of the coal fields; namely, St. Helen's, Wigan, Bolton, and Oldham.

3158. Is it the same district which is represented by Mr. Swallow?—Yes.

3159. Mr. *Baird.*] Are you the secretary?—I am an agent employed by the Miners' Association; I have been about 12 months an agent.

3160. *Chairman.*]

3160. *Chairman.*] What is your trade?—I have been brought up in mines for about 30 years; I commenced at 10 years of age.

3161. What has been your principal occupation?—Cutting coal. I have gone through all the various processes which are gone through by coalers in our district, from a waggoner to a pickman.

3162. Have you ceased working?—I have not been working in a pit for rather more than a year.

3163. Are you now exclusively employed as an agent for the Miners' Association, having no other occupation?—I carry on a little business as a shopkeeper.

3164. Are you acquainted with the feelings of the men in your district?—As far as 12 months' experience will give it me, I have a general view of the feelings and views of the country.

3165. Do the men complain that ventilation is deficient?—In some collieries. Small collieries, in our district, are worse than large collieries.

3166. Do they complain that sufficient attention is not paid to accidents?—Yes.

3167. What are their complaints in general?—Their general complaints are a want of more air, and that better attention should be paid to the air being circulated properly through the workings of the mine. The men not unfrequently complain of being wound up and let down too fast. In point of fact, I have seen myself accidents occur, through too many men being let down a mine; and when they had got to the bottom not having sufficient light to see their way out; they have sometimes been pulled up again with one leg out, and I have seen instances where men have been pulled to the top, and have not had an opportunity of getting out. That evil might be remedied, if it were insisted that the hooker-on should be at his post in the morning, and have a light to enable the men to see their way to get out; but when they are let down in great numbers, and have with them their picks and other things which they work with, and have not sufficient time given to them, these accidents occur.

3168. Do you attribute those accidents to improper men being employed to take care of the engine, or to what cause do you attribute them?—Not exactly to improper men being employed. The man had good abilities to manage the engine; but the men being ready in four different places to get in at the top, and having no light at the bottom to see their way out, they were not able to get out with the same advantage as they get in at the top.

3169. Does not the man who has the charge of the bottom of the pit go down before any of the men?—No.

3170. Mr. *Locke.*] Does the engine-man start his engine back again, unless he gets a signal from the bottom?—Yes.

3171. Then, in point of fact, the accidents of which you have now been giving an account, might be prevented, if the engine-man was not permitted to start the engine until he got a signal from the bottom of the shaft?—Yes.

3172. You have stated that you have known accidents arise from the speed at which men are drawn up and let down?—That has occurred when they have been let down so quickly; and it has had such an effect on their mind or body as to prevent their having proper recollection how to act under such circumstances.

3173. In those cases, do the men ride in a tub or on the rope?—In the district in which I live, four men and a lad generally come up in a box; but there are places in Lancashire where six or seven are allowed to go down, and as many as 14 or 15 in a gang; this increases the difficulty. I have frequently heard the men complain of that, and they think they ought not to be allowed, however good the machinery may be, to go down in such great numbers.

3174. Why do the men go down in those great numbers?—I suppose the reason simply is that there are so many to go down, and there is only a certain amount of time allowed to let them down. That is a rule established on the ground by the master.

3175. What rule does the master establish?—For so many men to go down.

3176. Is there such a rule at the collieries in Lancashire?—In the colliery in which I worked four were allowed to go down together.

3177. Do you consider that four is unsafe?—I consider four to be sufficient where they wind six cwt. of coals at once, and where the engine will pull a tub from the bottom, 250 yards, in a minute. We think that three men and a lad is sufficient.

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3178. Do you know whether at collieries where seven or eight men are allowed to go down at one time, there is any rule by the proprietors, fixing the number to seven or eight?—I do not know that the proprietors have a printed rule that this shall be the case.

3179. Can you tell the Committee whether, in point of fact, it arises from any rule at all, or from the will of the men themselves?—I cannot state whether they have a printed rule as to the course that shall be pursued; but when proprietors or agents observe men taking unwise and rash steps of that description, they ought to interfere, and not allow them to go down in such great numbers, for fear an accident should happen.

3180. Do you think that the mischief arises from the proprietors not preventing the men putting themselves into dangerous positions?—In some cases. I do not know that there is any law or rule to compel men to go down on that principle.

3181. You only know that the fact is that the men do put themselves in that position?—Yes.

3182. *Chairman.*] Is there a rule that the man at the bottom of the pit shall go down before any of the men?—Not at any colliery that I am aware of.

3183. Is the proprietor of the pit aware that the men go down before the man who has the charge of the bottom of the pit, and that there is no one at the bottom of the pit with a light to direct the men?—They are perfectly aware of it, from the complaints of the men; and I know that at one place, where two or three accidents have happened, upon complaints being made to the master the evil has been remedied; and he does not allow the engineer to start the engine until there is a knock from the bottom.

3184. Mr. *Locke.*] What is the usual signal in the pit to the engineman to start the engine?—When the men are going down in the morning, under that regulation, they ring once; then supposing they begin to work, and send up coals, they ring once; and they understand when the engine begins to perform its daily labour.

3185. Then, in point of fact, the regulation is, that when men descend a pit, the engineman is not to start his engine until they ring once?—Not at that colliery now.

3186. Can you mention any colliery where that regulation is not in operation?—Yes; it is not in operation at some collieries.

3187. Can you mention any colliery where the engine is permitted, without having the bell rung once, or without having a signal from the bottom?—I can mention places; I have worked at the concern of Lees, Jones, and Booth for 20 years.

3188. Where is that?—In Lancashire.

3189. What part of Lancashire?—It is just bordering on Yorkshire; it is near Ashton-under-Lyne.

3190. Near Oldham?—Yes. They have concerns in both towns.

3191. Was that the practice in that colliery?—It was the practice there, but I never knew an accident occur at that colliery through a neglect of that description.

3192. Can you mention any other collieries where the engineman starts the engine without having a signal given to him?—It was the general practice throughout that part of Lancashire.

3193. Do you mean that it is the general practice that the engineman starts the engine without any signal?—Yes. When the men get into the tub at the top, and shout out "Go on," he does not know whether the men are out of the tub at the bottom or not.

3194. Mr. *Baird.*] Is that system still in operation?—I do not know any colliery but the one that I have mentioned, where the engineman is forbidden to go on until the bell is rung once at the bottom.

3195. That is the instance you have stated?—Yes.

3196. Mr. *Locke.*] Do you know whether there was such a regulation at the colliery of Lees, Jones and Booth?—I am not aware. The discipline was very strict at the colliery of Lees, Jones and Booth.

3197. You cannot state whether this was prohibited by their rules?—I do not know that they have any rule in the office that it shall not be the case.

3198. You cannot positively state whether they have or not?—I cannot.

3199. You

3199. You speak only of the practice?—Yes; and the custom.

3200. Do you think that, if any suggestion had been made by any of the workmen themselves to the owner of the colliery, about this dangerous practice, he would have had any objection to prohibiting the men starting from the bottom without a proper signal?—I do not think he would, if the difficulty to which the men were exposed had been properly explained to him. At this place, as soon as the matter was properly laid before the master, he at once gave orders that the engine should not start until the bell rang at the bottom.

3201. *Chairman.*] Have you never known the workmen incur danger, contrary to the express orders of the overlooker or the master?—Yes; I know one man who took his lamp-top off, contrary to the orders of the overlooker.

3202. Do you think that if there was a rule that not more than six, or any given number of men, should go down a pit, and the men were in a hurry, they would not break it if they thought they could do so with impunity?—I think that the engineer ought to have the power, when he sees a number of men getting into a tub, to prevent any more from descending.

3203. Mr. *Locke.*] How can the engineer prevent that which he cannot see?—To the best of my knowledge, there are no engines fixed which the engineer cannot see, at the top of the pit.

3204. Do the men ever descend in the dark?—Not unfrequently.

3205. How would the engineman be able to judge if it were in the dark?—If it were in the dark, and he could not see, he would not be able to ascertain the number.

3206. Then the engineman himself would not have the best means of preventing such an improper practice?—I do not think that the custom of not having lights at the top ought to be allowed in small collieries or large collieries. I think that all caution ought to be attended to.

3207. *Chairman.*] In your district are the pits properly walled, or do accidents occur from stone or other things falling on the heads of the men?—We have an improved system to what we had formerly; formerly we used to get our coals, and rob the pit's back, without building cross walls.

3208. Mr. *Cobbett.*] You have spoken of a rule as to the number of men going down in a tub; at what time do they go down in the morning?—At the colliery at which I last served for 10 years, the system which was pursued was the best system that I ever observed in Lancashire. We commenced descending the pit at six o'clock in the morning, and we were allowed, generally speaking, half-an-hour to let the men down.

3209. Was that done by a rule?—By a rule; the engineer had from six o'clock to half-past six to let the men down, and from half-past six to seven o'clock to arrange the machinery, and get all ready for pulling coals out.

3210. Then the men begin to go down the pit at six o'clock?—Yes.

3211. Do they assemble in any number at the mouth of the pit, and stand waiting to be let down?—Generally, they begin to come from five o'clock to six o'clock.

3212. At six o'clock are there a large number waiting to be let down?—Sometimes a score, and sometimes there may be thirty; it is according to the number of men who are employed in the pit.

3213. Is there always half an hour allowed for the purpose of letting the men down?—Yes.

3214. Have all the men who assemble at the pit to be let down in that half hour?—Yes.

3215. How many men would the tub in which they are let down, hold if it were filled?—The boxes will hold six cwt. of coal; and generally three men and a boy go down in a box.

3216. Is there any rule, either printed or given out by the manager, as to the number to be let down in every box?—If the ropes are in good order, they have no objection to four; if they happen to see a place giving way, they prohibit so many going down for a week or two.

3217. Do you mean to say, that if they saw that a rope was giving way, they would let anybody down?—Yes; I have seen instances where it has been worked for weeks, when they have seen that it has been giving way.

3218. Do not you consider that is an evil which ought to be remedied?—They generally consider that the banksman, the engineer, and the carpenter

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are able to judge whether the rope is going fast enough or not, or whether it is liable to break.

3219. You have stated that you have known instances in which 13 or 14 men went down in a box?—Yes; a man told me, about five or six weeks since, that 14 or 15 were allowed to descend at once.

3220. Did he tell you where that was allowed?—Yes; at Mr. Knowles' colliery.

3221. At what place?—I think he called it Yates Croft.

3222. Do you know where it is?—No; I do not exactly know the particular spot.

3223. Of your own knowledge, can you say that as many as 12 or 13 men have ever been let down in a box at one time?—I never saw it myself. I heard a man once state that he worked at a colliery, and that the only objection he had against working there was, that so many men went down together. I asked him how many went down together, and he said that he had seen as many as 19 or 20. I asked him how they got down into the boxes or skips; and he said they were one above another, and that when they got to the bottom they were liable to be lamed. I have never seen that number myself.

3224. Did you ever see more than four men go down together in a box?—Yes; I have seen five and six.

3225. Where?—I have seen five and six at the colliery where I worked.

3226. At Lees, Jones, and Booth's?—Yes; at both places.

3227. *Chairman.*] Do you conceive that there is any danger in five or six men going down a pit, if the engine goes at a fair rate?—Yes; and for this reason; pits are not always examined every fortnight, as I think they ought to be. There is a liability of the rods getting loose, and on that account allow the skip to have more play than it ought to have, and by that means getting what we call out of gear. If there are so many thrust up together in a tub, they have not that opportunity to arrange themselves which they ought to have. On that account I think it ought to be prohibited.

3228. You are speaking of pits where there are guides?—Yes.

3229. Are there any pits, in your district, which are worked without guides?—I am not aware of any at present; there have been some.

3230. Mr. *Stephenson.*] Do you think it is possible, if anything goes wrong when men are descending, to give a signal to the engineman, in order to avert the danger?—If the engine is not winding too quickly, there is a possibility of doing that. If it is going fast, there is not an opportunity of seeing the ropes swag.

3231. Did you ever give a signal of that kind while you were descending?—Scores of times.

3232. You have rung the bell when you were descending?—Yes; and in ascending also. I have known the gearing to be off, and the bell-line broken; and, if the engine had been going fast, the probability is that we should all have been thrown down the pit; but as the engine was going slowly, we had an opportunity of ringing the bell, and by that means of informing the engineman that something was wrong, and conduct themselves safely to the top.

3233. *Chairman.*] Do you think it is desirable that regulations should be enforced by the Legislature for the safety of men going down the pit, or would you rather leave it to the discretion of the masters themselves?—I think that there should be a law that such regulations should exist in small collieries and large ones.

3234. In order to establish those regulations, would you recommend that the coal owners should consult together with the men, in order to adopt certain regulations which might become general in the country, and which would be both advantageous, and generally adopted by all parties?—I should have no objection to the coal owners, the engineer, and the workmen consulting together. I think that the best plan of preserving men from being hurt should be adopted. I do not think there would be any objection, on the part of coal proprietors, to carrying out the best plan.

3235. You would not make any regulations which would interfere with the coal owners, more than you could possibly help, to prevent accidents and loss of life?—If I had the law to make, according to the knowledge that I have, I would not make a law which would in the least infringe upon the rights of any individual,

individual, further than that I would establish laws, rules, and regulations which would prevent, as far as possible, accidents and loss of life. That being done, I think it would be as much as is essentially needful; and I think that the men generally would be satisfied.

3236. From your knowledge of the men, do you think that a code of laws could be adopted which would satisfy the men, and also satisfy the coal proprietors and the head-viewers?—Perhaps we could not strike out a law which would satisfy all parties at present; but I think that if a law were established, we might gather such information from time to time as would both satisfy the employers and employed. I do not think at present we should be able to satisfy all parties. I think it wants a beginning.

3237. Mr. *Ingham.*] You think that as your information enlarged you might devise terms which would be agreeable to both parties?—Yes.

3238. *Chairman.*] Did you hear Mr. Swallow's evidence with regard to the inspectors?—Yes.

3239. Do you agree with him, that the men are satisfied with the present system of inspection?—I believe the men are generally satisfied with the present system of inspection, but they think it does not go far enough. The general view of the men of Cheshire and Lancashire is, that there ought to be more inspectors. There are six who are now regularly looking at the evils which arise in the coal field; but we think that number is not sufficient.

3240. You wish their number to be increased?—Yes.

3241. Do you wish the number to be increased by having more inspectors, or by having the same number of inspectors, and a certain number of sub-inspectors, as Mr. Swallow suggested?—I think the general view of the men, as well as my own opinion, is, that we ought to have sub-inspectors; that is, practical men who are acquainted with the workings of the coal field, and are able to discover where the evils exist, and point them out to parties who have the power of remedying them; and that if they are not remedied at the proper time, and after due notice has been given proper measures are not carried out, then of course there ought to be some other law to which they might appeal to get the thing done.

3242. Would you give the sub-inspectors the power to make any alterations themselves, without applying to the inspectors?—I would give the sub-inspectors no further power, than that they should be able travel the workings through, and to take the size of the air-ways; I think that men might be found who would be able to tell the speed of the air; and they should also have power to report to the head inspectors where evils existed which they thought ought to be remedied, but that in the first place they should report to the manager or master of the concern.

3243. Who is the inspector of your district?—Mr. Dickinson.

3244. Do you agree with Mr. Swallow, that Mr. Dickinson gives general satisfaction?—Mr. Dickinson, as far as I am aware (and I happened to work at a colliery which he visited), has given great satisfaction, and the men were generally well satisfied with the things that he pointed out. A great number of evils existed at the time Mr. Dickinson visited the work, and I feel great pleasure in saying that there was no objection, on the part of the employers, to carry out any measures which he thought might tend to improve the working of the concern; they were speedily attended to, and were carried out as soon as proper arrangements could be made.

3245. Mr. *Cobbett.*] Do you mean that Mr. Dickinson suggested things, which were carried out in accordance with his suggestions?—Yes; we had four or five different places which had been driven in, built up, standing full of sulphur; and he suggested that those places should be opened, and that the sulphur which was lodging there, and liable to be exploded, should be properly carried off, and the air properly circulated through those places. According to his suggestion, the master carried out the plan, and all the places which were full of sulphur previously to his visit were entirely cleared out, and were much more safe.

3246. Mr. *Cayley.*] Do you think the master did not know that before Mr. Dickinson told him?—I can hardly say whether the master knew all these particulars or not; I do not think that masters generally know when there are evils existing in a mine, and the men are exposed to danger.

3247. *Chairman.*] Did not the viewer know it?—The viewer knew it perfectly well.

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3248. He did not take proper care to effect the improvements before Mr. Dickinson visited the colliery?—They were built up previously to his coming; and, after his suggestion, they were opened, and the sulphur cleared out.

3249. Believing, as you do, that the workmen, the masters, and the viewers are perfectly satisfied with Mr. Dickinson, do you still think it would be better to employ sub-inspectors under him, than to increase the inspectors, and have the same class of men as Mr. Dickinson?—It would not do to have the same class of men to attend to the work as Mr. Dickinson, unless there were a sufficient number to traverse the workings through. If there were a sufficient number of the same class as Mr. Dickinson, who would be able to visit the extreme parts of the workings, where the evils arise, as well as just visiting the collieries, of course the men would have no objection to that. A great number of evils exist at the extreme parts of the workings, and, if they were not properly gone into, whatever might be the number of inspectors, those evils would not be lessened.

3250. Would you give the sub-inspectors more power than to report to the inspector?—I would give them no further power than just to point out the evils.

3251. You would give them power to point out the evils; and, if the evils were not remedied, they should report the circumstances to the inspector?—Yes.

3252. What power would you give the inspector?—If, after it had been made plain by a sub-inspector that an evil existed, it was not remedied, the inspector should visit and give timely notice; and if it was not attended to, after such notice as he should think in his judgment was sufficient, I would give him power to stop the concern until some other authority had been consulted.

3253. Mr. Swallow stated that the sub-inspectors should report to the inspector, and that the inspector should visit the mine; and that if the inspector had any doubt, he should call in another inspector and consult with him, and that if those two gentlemen agreed on a plan, they should have full power to carry it into effect. Would you give the power to one inspector, or do you think the inspector should call in another inspector, and that those two inspectors, if they agreed on consultation, should have the power of stopping a mine?—I would not give to one individual the power to stop a mine.

3254. Under what circumstances, and to whom would you give the power, to stop the mine?—I would have a Central Board in London, and that Board should have the power to consult with the inspectors in extreme cases; and they should at once have the power to carry out measures for accomplishing the end which they had in view, whatever it might be.

3255. You are of opinion that if the sub-inspector's suggestion was not carried out, he should report to the inspector, and that the inspector should again fairly recommend the coal owner to carry out whatever he thought was necessary; and if it was not done, you would merely give to the inspector the power to report to the Central Board in London, and give the Central Board in London full power to stop the mine, or of doing anything else they thought proper?—I think that, after proper methods of that description had been taken, the inspector should have power to stop the mine.

3256. Without reference to the Central Board?—I am taking into consideration that they would consult the Central Board.

3257. What duties would the Central Board perform, according to your view?—They would simply act according to the evidence which was presented before them, as to the evils which existed.

3258. If there was a difference of opinion, between a head viewer and one of the inspectors, the head viewer being an eminent man, you would give to the Central Board power to call the parties before them, and hear the case on both sides, and then judge for themselves?—When a point of that description arose, and there came a dispute between persons of the highest abilities, I think it ought to go to arbitration.

3259. What mode of arbitration would you suggest?—I am not able to answer that question.

3260. You have not considered the question?—No.

3261. It is merely a floating idea in your mind, that there ought to be a Central Board in London?—Yes; it is an idea in the minds of the people generally.

3262. Had they that idea before they read the Report of the Committee of 1852, or have they adopted that view since they received the evidence?—Previously to that report, the men had ideas and views on the subject; but from want

want of ability, they were not able to put them into anything like form. We lack greatly in that respect. From want of proper tuition or cultivation of the mind, and proper learning, we are not able to put our ideas into such a form as we like.

3263. Mr. *Cobbett.*] What do the miners think of the Report of the Committee of 1852?—The miners were highly pleased at the conclusion to which the Committee came; and I fancied, in my own mind, that what would be most cheering to them was, that they pointed out that there ought to be a number of sub-inspectors; and we looked upon it in this light, that we should have more men looking at the evils which exist, and we should be able to point them out; and we were looking at that, as being the means by which our evils would be ultimately remedied.

3264. Mr. *Mostyn.*] By whom would you have the sub-inspectors appointed?—By the Government.

3265. Mr. *Cayley.*] Do you think that one use of the Central Board would be to appoint the inspectors and the sub-inspectors?—Yes; and that Board would have so much knowledge that it would be able to ascertain from a practical working man, whether his capabilities were such as would give a guarantee in employing him as a sub-inspector; and I think they would be able to inquire from him whether his practical knowledge was such as to guarantee them in appointing him.

3266. Do you think that another use of that Central Board would be, to see that all the inspectors and sub-inspectors acted on one uniform system?—Yes.

3267. *Chairman.*] Do you think it is possible to find a class of men for sub-inspectors who would give satisfaction to the workmen, the owners of mines, and the viewers?—Yes.

3268. Can you give the Committee an idea of the class of men you would appoint as sub-inspectors?—I think they should be working colliers. I would take them from the best practical men that we have in the coal field, and who properly understand, as far as practical knowledge is concerned, how a colliery ought to be carried on.

3269. Do not you think it is very difficult to find a working collier who has much knowledge of the mode of ventilating a colliery?—I think there are a great number of practical colliers, who have a better knowledge than a great many under-lookers who are now employed.

3270. The duty of a working collier is, to go into his work and remain in his stall, and cut coal all day long?—That is the duty they wish to enjoin upon them; but we live in times when they take other things upon them.

3271. What other things do they take upon them?—They study how things ought to be conducted, and that is the reason they are able to point out the evils which exist.

3272. You think that, in point of fact, there are plenty of colliers to be found, who are capable of instructing the viewers in the best mode in which a colliery may be carried on?—A viewer you may, perhaps, take in a different light than we do. I think there are plenty of working colliers who have a better practical knowledge than some under-lookers.

3273. Take an under-looker. An under-looker is a man who is constantly in the colliery, and the viewer is a man who makes periodical visits. Is that the practice in Lancashire?—Yes. I would not say there are practical men who had as much knowledge as any under-looker; but I say that some of them have more knowledge. Of course, if they did not improve and prepare themselves, they would never be able to become under-lookers.

3274. Is it your opinion that there are a sufficient number of working colliers to be found, in whom the masters or head viewers of collieries would have confidence to be appointed sub-inspectors, and come down into the place for the purpose of making suggestions as to ventilation and other parts of the workings?—Yes.

3275. Mr. *Ingham.*] What have the under-lookers generally been before they got their appointment?—All the under-lookers whom I know have generally gone through the regular process, from a drawer-up to a pickman.

3276. Does the under-looker come from the same body of clever miners from whom you would select the sub-inspectors?—Yes.

3277. *Chairman.*] Do you think it is necessary they should receive any education?—I would take them as they stand; I would commence the system as it

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is, with the best materials I have; and then at a future period this duty should be instilled into rising colliers and sub-inspectors, and on managers and under-lookers also.

3278. Mr. *Locke.*] Supposing that the Central Board in London entertained a different opinion to you, and thought that young men educated in some central establishment in London would make better under-lookers, what would the workmen think of appointments of that kind?—I think they would be dissatisfied. I think that the workmen have an opinion, that no one is so well qualified to answer their end, or so well able to point out the evils that exist, and get them remedied, as a man who has been practically trained to it from his youth.

3279. And therefore you think that any appointments of that kind which were made by the Central Board in London would not give satisfaction?—I think it would not give general satisfaction unless the sub-inspectors were taken from the class of workmen.

3280. How would you appoint the Central Board in London for the purpose of making it satisfactory to the general body of workmen?—If the Central Board in London should have power to examine the head inspectors and the sub-inspectors, they ought of course to have superior abilities to either of those two separate classes. In that respect, not being properly educated, I am hardly able to speak as to the class.

3281. Then, in point of fact, you speak of the Central Board as something upon which you have not made up your mind of whom it is to consist?—We look at it in this light, that if the Government appointed a Central Board, we have faith that they would appoint men who were qualified to look into the evils that exist, and to point out the remedies for those evils.

3282. Whether they should appoint such persons from the working miners to take the sub-inspectors' position, or whether they should appoint young men who had been educated in a central school in London, you cannot state?—No.

3283. But you hope they will appoint the working miners?—Yes, we hope so; and we think that unless that were done it would not give general satisfaction.

3284. The Board which is to appoint these persons ought, in your opinion, to have a practical knowledge of mining?—If it were driven into that kind of argument it would destroy the Board, because men who are brought up in a mine have not the opportunity of getting those abilities which would be required.

3285. Do you think it would be an advantage that the persons composing the Central Board should have any practical knowledge of mining?—It might be an advantage.

3286. Do you think they would be competent to appoint or to examine proper persons without having a practical knowledge of mining?—I hardly think they would.

3287. Mr. *Cayley.*] Do you think that if the Government were to determine to put an end to the evils which now exist in mines, they would have, for any long time together, any difficulty in finding men equal to the duty?—No; I believe that if the Government came to such a conclusion, they have already obtained such an amount of information that they might come at such as would be able to remedy all the evils which the colliers generally complain of.

3288. Supposing there were some difficulty at first in finding proper men to fill the office of sub-inspectors, did you ever know, in your experience, of a demand for an article in this country, without a supply very soon growing up, which was equal to the demand?—No.

3289. *Chairman.*] In order to get good men, would it be necessary to pay them well?—Yes, they ought to be paid well, in order that they might be out of the reach of what we call temptation, or inducement to do things which they ought not to do.

3290. Mr. *Cayley.*] Do you believe that all that is wanted for the purpose of securing an improvement in the present state of the mines, for the safety of the working men, is a thorough determination on the part of the Government to secure that object?—Yes. I believe that now, if the Government said, on behalf of the mining population generally, "We will commence with the means we have, and we will remedy the evil as far as we can," they would be able to do it, and they would be able to obtain information which would point out evils of which at present they are not aware.

3291. Mr. *Cobbett.*] Supposing the Government appointed a set of sub-inspectors,

inspectors, equal in capacity to the present inspectors, would not those sub-inspectors satisfy the miners?—They might satisfy the miners, but I do not think they would. As far as I am individually concerned, I would have men who had been properly trained from their childhood to be familiar with the evils of which colliers generally complain.

3292. *Chairman.*] You would rather prefer that they should be practical men, than men having scientific knowledge?—If I could not meet with men who had scientific knowledge, and practical knowledge also, I would commence with the thing as it is. If I could meet with men who had a scientific knowledge, and also a practical acquaintance with mining, those are the parties to whom I should give the preference.

3293. In your opinion, has the present system of inspection been beneficial, as far as it has gone?—I think it has.

3294. Do you think that the ventilation is better now than it was before the inspectors were appointed?—Yes.

2295. Do you consider that that improvement is to be attributed to the inspection?—Yes. I am perfectly aware of one concern, where no less than 15 lives were lost in less than two years, with the ability to have ventilated the mine; and that, under their suggestion, the evil has been remedied, and they are not exposed to anything like it now.

3296. Do the men wish this Committee to recommend any particular system of ventilation.?—No. We are perfectly satisfied that there are means at hand, which are capable of answering all the ends we want in that respect.

3297. What they want is, a sufficient supply of fresh air to preserve their health, and to keep the mines free from explosion?—Yes; and the air to be properly circulated.

3298. Would it be possible to keep a mine free from explosion, however much air was carried into the pit, unless it was properly circulated through that pit?—No.

3299. Is it the custom in your district to split the air?—I do not see how a mine can be ventilated without splitting the air.

3300. Is the system of splitting the air generally adopted in your district?—Yes.

3301. Is it more adopted now than it was before the appointment of the inspectors?—I cannot speak to that.

3302. In your district, is sufficient care taken to keep the airways in proper order and to keep them of sufficient size?—At some places; and at others it is not so. Some places are very well ventilated; I have worked 20 years at one concern; they have a very extensive coal field; and they have never had what we call a serious explosion.

3303. Is that a very fiery seam?—Yes; it is what we call the Black Mine, and it is four feet thick.

3304. Did you ever hear the colliers complain of having too much air?—No; I do not remember hearing anything of that description, in its proper circulation. I may have heard a man, when he has been close to the shaft where all the power of ventilation has been on, say that it was very cold; but when it has been properly distributed, I do not recollect an instance.

3305. Do the workmen agree with the Report of the Committee of 1852?—Generally speaking, I think they do.

3306. You do not mean to state that they agree to every paragraph of the report?—No; I think what they rested on most is, that the Committee suggested that a sufficient number of sub-inspectors should be appointed, and that they would be able to point out the evils which exist.

3307. Do the colliers object to the use of the safety lamp?—Not generally.

3308. Do you agree with the Report of the Committee of 1852, with respect to the safety lamp?—I have never read the opinion of the Committee on that point.

3309. Is it your opinion, that the use of the safety-lamp in very fiery mines ought to be made compulsory?—Yes.

3310. You do not say that with a view of making the ventilation worse?—Not in the least.

3311. You think that the first care should be, to see that as much ventilation was brought into the mine as possible; but that, as an extra safeguard in fiery mines, the safety-lamp should be used also?—Yes.

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3312. Would you confine the use of the safety lamp to the neighbourhood of the goaves, or to any particular district of the mine?—I think that, as far as possible, there ought to be attention paid to clearing the goaves of the foul air.

3313. Do you think it is possible to clear a very large goaf?—We have a firm who are working out on one side of the pit close to 2,000 yards, and about 600 yards on the other side; and the system they adopt is, to build what we call cross walls; they put a three-yard wall in every eight yards. They keep as much as possible their top air road safe and clear, and up these wall ends they have now a system of what they call rambling the air; that is, after they have taken the air through all the various splittings, to circulate it through each mine; they have a system which they call turning it out and allowing it to go up these different stalls or wall ends, and find its way out at the top airways; and that is a good system of clearing the goaves. We can sometimes go as far as 200 yards back; and then the surface coming down gently, and the floor heaving up, these goaves come together without those serious falls, and driving the sulphur back on the workmen. When they are going to leave off 100 yards at the further end, they so make their preparations as to have a fresh preparation made to carry the air into the back air road. These are means of preventing accidents by driving the sulphur on the top of the men, and that is a good system.

3314. Where is that system adopted?—Lees, Jones, & Booth carry on that system extensively; they have another plan, which has been worked advantageously both for the men and for themselves. When they are opening a new coal field, they will, as soon as possible, get a road round the boundary of the coal field; it drains the sulphur out of the body of coal which has to be worked. They can work the body of coal at rather less expense, and with more safety to the men.

3315. In that case, would it be necessary to open out the pit a long time before you wanted to raise any coal?—Formerly, when we were getting what we call the crop coal, we had not the same evil to contend with; we are now getting more on the dip, 600 or 700 yards down; so that these preparations are made regularly as they go on, and perhaps commence a twelvemonth previously to its being required to be worked out.

3316. Have you considered the question of refuge stalls?—That is a subject to which I have not paid attention.

3317. Do you prefer ventilating the goaf to stopping up the goaf?—From my practical observation of stopping up the goaves or walling them off, the men are of opinion that it is an impossibility to wall the sulphur off; it will break out. We would rather have the goaves cleared, if it is possible to do it.

3318. If it were not possible to clear the goaves, in your opinion could the goaves be closely walled up, so that as little gas as possible should escape?—Yes.

3319. Do you think that a good current of air should at all times pass round the goaves, whether they were stopped up closely or not?—Yes, close up to the face of the goaves.

3320. With regard to accidents from falls of roof, Mr. Swallow stated that two modes were adopted in your district; namely, having a deputy to stand the timber, or the men standing the timber themselves. In your opinion, which plan is most safe?—Being a practical man myself, I should prefer setting my own timber. I think there is less danger, when a man comes to draw what we call a set of posts. After he has cleared it out, he is the best judge on which post lies the greatest weight; and it is not always the case that a master wishes you to draw that post. When you know on which post the greatest weight lies, you may sometimes get half a dozen round that post, while, if you took that post it would bring all in together.

3321. Then you do not agree with the evidence of some of the Northumberland people, who stated to this Committee that the deputies, being constantly employed in sounding the roof and in standing timber, would be much more likely to put the timber in a safe position, than if the collier was obliged to stand his own timber?—If in Lancashire it was the rule that we had to wait until a deputy came, we should not unfrequently be lamed; so that I think it is the duty of every workman to set his own posts.

3322. Throughout your district in general, is sufficient timber given to the men for the purpose of standing?—Generally speaking, they have to go through the proper process, but there is generally timber at their command.

3323. Have you heard any complaints in that respect from the men?—No.

3324. With regard to verdicts, do you agree with the evidence of Mr. Swallow, that the present system of coroners' juries is not satisfactory?—I think that, generally speaking, juries are composed of men who do not understand the system of the coal field; and that being the case, they are not able to glean that amount of information which they ought to possess on those subjects. We should like the system to be altered, if it were possible to alter it advantageously.

3325. Mr. *Ingham.*] You would wish to have a body who were more competent to examine into the origin of accidents?—Yes; I think that at least some of the jury ought to understand the nature of a coal pit, that they might be able to get information of parties who gave evidence of the circumstances which transpired.

3326. Mr. *Cayley.*] Have you ever known a case where a verdict has been given, as you considered, contrary to the evidence?—I have known cases in which the public have complained of the evidence which had been brought forward, and thought that the parties who were concerned ought to have been punished one way or another.

3327. Have you ever known deaths to take place, where the evidence seemed to implicate the mode in which the parties had been destroyed, and the verdict of the jury given contrary to the evidence?—I do not know it from my own observation; I have heard complaints of that description; I heard a person state that he was once on an inquest of that sort, and had to give opposite evidence, as Mr. Swallow stated the other day.

3328. Mr. *Locke.*] Have you often heard, in other cases as well as mine accidents, that the verdicts of juries have not been consistent with the evidence?—I have heard such complaints made.

3329. Mr. *Baird.*] Did you ever attend a coroner's inquest?—Never.

3330. *Chairman.*] Is there any other point, connected with this inquiry, upon which you wish to give evidence?—I think, if the Legislature do legislate upon this subject, there ought to be a law that all collieries should have a system of ventilation, either by the furnace or the steam-jet.

3331. That is, that a colliery ought not, under any circumstances, to be carried on by natural ventilation?—No; I think that a great deal of evil exists in small collieries, from black-damp and such things, which are never noticed, and which are detrimental to health.

3332. Mr. *Ingham.*] You state that, in almost all collieries, you think there could be discovered some able practical miners who would be competent to fill the situation of sub-inspectors?—I think they might be found in the country; I do not say they would be found in every colliery.

3333. In every coal field?—I should think so.

3334. From your knowledge of this class of men, do you find a disposition on their part to avail themselves of opportunities of getting information from books?—On the part of several there is such a disposition; but it is not so general as I should like to see it.

3335. Do you think that the best practical miners have a desire of improving themselves by reading and learning?—Yes; I think that if schools were established, in which miners' children received an education for so many years, similar to that which is received by factory children, we should in a few years have a superior class of miners than we have at present.

3336. You said that it was very likely that, at first starting, the men who would be chosen as sub-inspectors might not have so much information as you would wish. If local mining schools were established, do you think this class of men would be willing to give some of their spare time, if they have any spare time, to improve themselves by study and learning?—Yes; I think every well-disposed man would avail himself of every opportunity which was calculated to elevate him in society.

3337. Do you think that is the disposition of these men?—I think there are colliers who are disposed to do so.

3338. If they had some accessible mining schools, do not you think, although they might not at first be adequate in every respect, yet that after practice for a year or two they would be competent as sub-inspectors, both from their scientific knowledge as well as their practical knowledge?—Perfectly.

3339. Would it be very desirable to establish, in the neighbourhood of all

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great coal fields, some kind of mining schools, where men, if they were so disposed, might obtain the requisite scientific information?—Yes; and I think also, that as far as the Government has control, or as far as the Board in London has control over the present class of schoolmasters which exist in the district of cotton manufactories, if their attention was turned to training young men up to the study of these things, and showing them the importance of them, at a future time we should see fruits springing up which we never expected.

3340. Mr. *Cayley.*] From what you have stated with regard to ventilation, are the Committee to understand that, although no explosion may have taken place, yet that the state of the ventilation is very insufficient?—Yes.

3341. And that although the destruction to life may not be so immediate from fire-damp, yet that, from the existence of black-damp, the health of the miners is so prejudiced, it is equally sure in the end?—Yes. I have seen instances of that description. I have seen what we call a waggoner, who for three or four days together never could have a light, except at certain places. When we have been getting coal in certain places, we have had to stick our candle a few yards off. Scores of times I have put my hand, as if I thought it would have prohibited our light going out. Since then, I have thought about the subject, and I was absorbing the air which kept the candle alive, although it was useless to do so; but being out of breath, and having little air to breathe, these are the difficulties; and the sufferings of the men in this respect are almost incredible.

3342. How did the candle burn under those circumstances?—We had to burn three candles generally, where we ought to have burned only one. Then there is an additional difficulty with the partly-burnt tallow; and there is the smell of the wick, which hangs down sometimes three inches long, not all burnt. This arises from the want of proper ventilation.

3343. Why did you hold the candle downwards instead of upwards?—Simply that if it is held straight upwards, the air is so light that the blaze would go off. If we held it horizontally, it gets partly fed, and it keeps a clearer blaze; so that it keeps the candle burning on that principle, which it would not do if it were held straight up.

3344. You mean to say that the amount of fresh air was so small, that the candle would not burn in an upright position?—Yes; I have seen that hundreds of times.

3345. Do you think the working men would be satisfied with less wages if the ventilation was better?—I think that if the ventilation was better a concern would be worked for less money; but all these difficulties make the collier's wages less. He has these difficulties to encounter for the same amount of money as he would receive for work in pure air.

3346. *Chairman.*] Do they generally cut coal by the ton?—Yes.

3347. Therefore, if the ventilation was better they would cut more coal in a day, and possibly for a less price per ton, which would be cheaper to the coal-owner?—Yes.

3348. Mr. *Cayley.*] Has it come within your experience that the miners have said they would be willing to work for less wages if the atmosphere was more healthy to work in?—To the best of my knowledge I have never heard them say so with reference to black-damp; but, with reference to fire-damp, I have frequently heard the colliers state that they would rather work for three-pence a day less, where there was no sulphur, than they would where there was sulphur.

3349. *Chairman.*] Is there anything else you wish to state?—I should like to see the day come when the Government stated that there should be a law passed that miners' children should have a proper and good education.

3350. Would you make it incumbent on the miner to contribute so much in the pound of his earnings towards educating his own children?—I think they would need no compulsion; I think they would feel disposed to pay the same amount towards the school that the factory people pay.

3351. Mr. *Locke.*] Can you state why they do not do that now?—I think that all families who have the opportunity of sending their children to school are willing to do it now, but the law is different. I could take my child into a coal field at 10 years of age, and I could work it any number of hours I thought proper; but if I wanted to take my child to a factory at 10 years of age, the law says that he must only go six hours the day.

3352. *Chairman.*] Do you think that a law preventing a man from sending his

his child into a coal-pit before he was 14 years of age would be generally satisfactory to the workmen?—Yes.

3353. Mr. *Locke.*] Do you think that, if that were done, the workmen themselves would take up the question of education, and properly educate their own children?—I think that there would be no general objection to paying the same amount per week that the factory folks pay for their children.

3354. They would not ask the Government to contribute anything towards the support of their school?—I think they might be disposed to say, that the same privilege which is granted to schools for the education of factory children ought to be granted to them.

3355. And no more?—I do not think they would ask for more.

3356. Mr. *Cayley.*] At what age do they enter a mine now?—Ten years.

3357. Is there a general opinion that fourteen years should be the age?—I do not think it has been taken up generally amongst the miners to ascertain the general opinion. I have heard individuals state, that fourteen years of age is quite soon enough for a child to go into a pit.

3358. *Chairman.*] Take the case of a man having a very large young family, the eldest of whom is ten years of age, and the whole of the children entirely dependent upon him for support; do not you think he would complain, if by law he was obliged to maintain his child without putting him to work until he was fourteen years of age?—I think that if you were to say twelve years of age it would perhaps give more general satisfaction. There would be instances in which men would complain; for instance, if a person wished to get from his children all he could in their infancy, he might use it, and give them no education at all.

3359. Your opinion is, that the right-thinking body of the working people would be satisfied with such a law as you have now stated, limiting the age to twelve years?—Yes; I think there would be no general objection to it.

3360. Is there anything further you wish to state?—No.

Nicholas Wood, Esq., called in; and Examined.

3361. *Chairman.*] ARE you still as extensively engaged as a coal viewer and manager as you were when you gave your evidence before the Committee of 1852?—Yes.

3362. The last question put to you by that Committee was this: "You are now very busy on the subject of these experiments with regard to the jet; when it is ready for examination, it is your intention, I understand you to say, to invite Mr. Forster and Mr. Gurney to see it, and you will have it fairly tested." Have you had the steam-jet fairly tested?—I have. Soon after the termination of the Committee in 1852, I made preparations to have it tested with the utmost fairness.

3363. Did you invite Mr. Forster and Mr. Gurney to witness those experiments?—We have a mining institute in Newcastle, of which I am president; and the secretary of the institute was desired to write to Mr. Gurney officially, to ask him to be present at the experiments; and he also wrote to Mr. Forster. I had myself seen Mr. Forster several times, and invited him to be present at the experiments.

3364. Were they present?—No. Mr. Gurney wrote to the secretary, to state that it was inconvenient to him to come down to witness the experiments; and Mr. Forster, when the day came, stated that he was not able to attend.

3365. Will you give the Committee, in detail, some of the experiments which you made?—The three principal collieries at which I tried the experiments, were Hetton, Killingworth, and Tyne Main. The Hetton Colliery is 900 feet in depth, and the jets were placed at the bottom of the pit; the boilers, and consequently the fires of the boilers, being also at the bottom of the pit, the heat of the fires from the boilers passed into the upcast shaft, and added to the ventilating power of the shaft, as well as to the mechanical power of the jets. The upcast is 153 feet in area; and there are two downcasts which are respectively 98 feet and 58 feet area, together 156 feet. The ventilating power at the Hetton Colliery generally is by three furnaces, one being nine feet in width, and the other two eight feet each. Figures 3 and 4, Plate I., is a section of the Hetton shaft showing the application of the three furnaces, B, B, and C, and of the boilers A, A, from which the steam was obtained to supply the steam-jets. The pipe

Vide Experiments, on Furnace and Steam Jet Ventilation, Appendix to Third Report.

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pipe leading to the steam-jets, is shown at D, Figure 8, in the same plate, shows the disposition of the jets placed in the shaft at G. Figures 6 and 7 show elevations of the furnaces. The diameter of the steam-pipe D, was six inches; and in the experiments three sets of jets were used at different times, being respectively $\frac{3}{16}$ths, $\frac{2}{8}$ths, and $\frac{3}{8}$ths of an inch in diameter, for the purpose of showing which size was the most effective.

3366. At all times were there the same number of jets, but of different diameters?—Yes; the number being 37 in each case.

3367. What is the extent of the workings of the Hetton Colliery?—The workings of the Hetton Colliery are spread over an extent of upwards of 2,000 acres, comprising coal partly worked, and coal standing in pillars and goaves.

3368. How many shafts are there in that colliery?—Five.

3369. How many upcasts?—Two upcasts and three downcasts; but at that part of the colliery which was the subject of the experiments, there were only two downcasts and one upcast, and, as I before stated, the two downcasts comprised 156 feet in area, and the one upcast comprised 153 feet in area.

3370. Mr. *Locke.*] Was there any connection between the other parts of the mine at the time of that experiment?—No; except a small portion of air, which was brought from the other colliery to the upcast, which is mentioned in the experiments. Table No. I, in the Appendix to the Experiments, shows the extent of the ventilation. The total quantity of air sent down the downcast shafts, amounted to 210,000 cubic feet per minute. And the synopsis shows the distribution of that air round the workings of the mine, and the length of run of each current of air. It will be found, on summing it up, that the total distance which the different currents of air travel, is 97 miles 1 furlong, and 100 yards. At some period of traversing the workings that is split into 33 divisions.

3371. The 210,000 cubic feet per minute refers to the whole colliery?—Only to the colliery which was the subject of the experiments.

3372. Mr. *Stephenson.*] That quantity went down the two downcasts, and came up the upcast?—Yes; I have set aside that part of the colliery which comprises the other two downcasts and one upcast. I will go on with that division of the colliery which comprises two downcasts and one upcast, the extent of run of air that I have stated, and the subject of the experiments.

3373. Mr. *Locke.*] Have you taken that extent into your computation?—I have, in all the experiments with the jet and the furnace; they were subjected to a drag of air equal in the aggregate to 97 miles, and sub-divided as shown in the synopsis. I found it necessary, in carrying out the experiments, to divide the power of ventilation under the different heads of,—natural ventilation;—engine fires alone;—engine fires and steam;—and then of engine fires, steam and jets. Then the furnaces;—the furnace engine fires and steam;—and the furnace, engine fires, steam and jets. I found it necessary that that should be done, in consequence of the evidence which was given in 1852, attributing to the jets that which did not belong to the jets as a mechanical force, but that part also of the ventilation which was attributable to the heat of the engine fires, and to the heat of the steam when the jets were placed at the bottom of the shaft. The natural ventilation, and the boiler fires, and the steam, independently of the mechanical force of the jets, produces a certain amount of ventilation, and then we have the mechanical force of the jets. I found that unless they were so divided, I could not arrive at a correct measure of the force of the jets.

3374. *Chairman.*] You had no opportunity of trying the jets without the aid of artificial heat?—Not when the jets were placed at the bottom of the pit; but I will give afterwards, at Tyne Main, experiments with the jets placed at the top of the pit, acting without the artificial aid of the boiler fires and the steam. There being a difference of opinion also as to the effect of the jets placed at the bottom and at the top of the pit, it was necessary to go into them in both modes. Table I. shows the experiments made at the Hetton Colliery, on the 12th October and the 3d November; Table II. shows the experiments made on the 29th October, 30th October, and 31st October; Table III. shows the experiments made on the 13th November; Table IV. shows experiments made on December 11th; Table VI. shows experiments which were made on 3d January 1853; Table VII. shows experiments which were made on 8th January 1853. I will take one of those experiments, as an example of the whole, to illustrate the mode in which they were done. I will take the experiments which were made on 29th, 30th, and 31st October, which are contained in Table II. On looking at that table,

Vide Experiments, Appendix to Third Report.

table, it will be seen that the first experiment was made with the three furnaces and the boiler fires, the steam blowing into the shaft, just as it had been when the pit was working; so that in that experiment we had, the natural ventilation, the boiler fires, and the steam; and it will be seen that that gave a ventilation at 6h. 30m. P.M. of 205,615 cubic feet per minute; and at 7h. 30m. P.M. it gave a ventilation of 201,274 cubic feet per minute. When these were in operation, viz., the boiler fires, the furnaces, and the steam, we applied the jets; so that the next experiment was, the jets in addition to the boiler fires, the three furnaces and the steam; and in that application it would be an auxiliary to the furnace system, the steam being at 40 lbs. to the square inch. The next experiment therefore was, the mechanical force of the jet over the three furnaces, the engine fires, and the steam, and the result was 205,636 cubic feet per minute, making for the mechanical force of the steam-jets 4,362 cubic feet of air per minute. The experiment then ceased, so far as regarded the test of the power of the jets; and the furnaces were put out, the engine fires were damped, and they remained out until 6. 30 A.M. the next morning; that is, from 40 minutes past 10 P.M. on the 29th until 6. 30 A.M. on the 30th, there were no furnaces and no artificial ventilation at all. The temperature of the shaft cooled down from 170° or 173° to 83° or 85° at ten fathoms down, and midway from 180° to 85°. We then had nothing but the natural ventilation, or the heat of the shaft alone, without any extraneous power. This must not however be considered to be the natural temperature of the mine; the shaft was not quite cooled down to the temperature of the mine, because the temperature of the mine, as will be seen by the experiment, was 64°; so that there still remained in the shaft 21° above the natural temperature of the mine. That being the case, the boiler fires were lighted and the steam got up and made to blow into the shaft; and then, in addition to the natural heat of the shaft, we had the power of the steam in the shaft without being in the shape of a jet; it was blown off quietly into the shaft, and not in the shape of a jet.

3375. At the same pressure?—At 50 lbs. The quantity of air which was then obtained was 139,176 cubic feet per minute. That gives an amount of rarefying power to the steam of 8,286. The jets were then set on, the steam being at 50 lbs. to the square inch; 37 jets, each three-sixteenths of an inch diameter, were set on; and the quantity of air at 12. 30 P.M., two hours after the jets had been set on, was 149,284 cubic feet per minute, making an increase due to the jets of 10,108 cubic feet per minute. At 2. 30 P.M., the quantity was 150,873 cubic feet per minute, making a difference of 11,697 cubic feet per minute. I should observe, on observing the temperatures in the upcast shaft, one effect of the jets, it will be seen, was to increase the quantity of air, and the quantity of air being increased, consequently increased the intensity of the boiler fires; and there was, therefore, a higher temperature in the shaft. The temperature in the shaft had increased from 98° to 105°. In estimating the increased quantity of air derived from the mechanical force of the jets, you must deduct the effect of the increased temperature of the shaft, by the more vigorous boiler fires. I will afterwards separate that, when I go into the general experiments; because I did not like to depend on one experiment to determine any particular question. Things being in that state, the boiler fires and jets being at work, at 2. 50 P.M., (that is, 20 minutes after the previous experiment was made,) the furnaces were lighted; and at six o'clock, that is, three hours and ten minutes after the furnaces were lighted, the quantity of air was 207,093 cubic feet per minute, which is 56,220 cubic feet per minute over the power of the boiler fires and steam-jets, the temperature in the shaft being now raised by the furnaces up to 164° from 105°. The furnaces were then put out, and the boiler fires damped; and they remained so until six o'clock the next morning, when the shaft was again cooled down to about the same temperature as it was on the previous morning; viz., 85°. This was done with a view of comparing the result of the two mornings; one with the boiler fires and jets over the natural temperature; and the other with the furnaces over the natural temperature; both being under precisely the same circumstances. The shaft, on the 31st October, was cooled lower than on the previous morning; because at ten fathoms from the top of the upcast, on the 30th, it was 83°, and on the 31st it was 79°, midway being the same. The quantity of air on the 31st, by the natural temperature of the shaft, was 104,414 cubic feet per minute, at 6. 30 P.M.; and, at nine o'clock, P.M., the furnace being lighted for two hours and twenty minutes, the quantity of air was 201,960 cubic feet per

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minute, being 97,546 cubic feet of air per minute over the natural ventilation, and 51,087 above the boiler fires and jets.

3376. Will you explain why, on the 13th of October, the temperature in the pit being at 85°, and the quantity of air 130,890 cubic feet per minute, while on the 31st October, under similar circumstances, the same temperature being in the pit at 85°, there were only 104,414 cubic feet per minute?—That arose partly from the upcast shaft not being quite so hot as on the previous morning; and it arose from the temperature of the downcast being higher on the 31st than it was on the 30th. The temperature of the downcast shaft at bank was 45° on the morning of the 30th, and on the 31st it was 52°. Of course there was not the same weight of column in the downcast shaft on the second day which there was on the first.

3377. Mr. *Stephenson.*] I observe that the barometer, on the 30th October, stood at 29·93, and that on the 31st October it stood at 29·75; so that there was some difference arising from the barometer?—Yes; it was at 28·9 in the morning of the 31st; and the barometer being lower, would give a less ventilating power.

3378. Therefore that is quite consistent with the result?—Yes. The next experiment, on November 13th, was made in the presence of several of the Government inspectors: Mr. Mackworth, Mr. Dickinson, Mr. Wynne, Mr. Dunn, and about 20 or 30 mining engineers, who also witnessed the experiments from their commencement to their termination.

3379. *Chairman.*] Were there any viewers present who were connected with the steam-jet system belonging to Mr. Forster?—Mr. Forster was not there, but his engineer was present; and I asked him to attend to the temperature and pressures of steam in the boilers, along with the Hetton Colliery engineer. Mr. Forster had promised that we should see the steam-jet experiments at South Hetton; and I thought it was very desirable that there should be no doubt as to the accuracy of both, and therefore I asked Mr. Forster to allow his engineer to test the accuracy of the experiments at Hetton, and that my engineer should test the accuracy of the experiments at South Hetton. Mr. Forster's engineer was consequently present during the whole of those experiments on the 13th November. The experiments on the 13th November were very full, and I would call the attention of the Committee to the diagram in Plate VII.

Vide Experiments, Appendix to Third Report.

3380. Mr. *Locke.*] Were the circumstances just the same under which the second experiment was made?—The mode of conducting the experiment was precisely the same. The jets, in that case, were quarter of an inch jets, instead of three-sixteenths of an inch on the previous days.

3381. Were the boilers the same?—Every thing remained the same except the jets. The three-sixteenths of an inch jets were taken off, and quarter of an inch jets were put in their place; everything else remained the same.

3382. Did the second experiment, tried on the 13th November, confirm substantially the previous experiments?—It did.

3383. You found no considerable discrepancy in the result?—No. I must, however, observe, in reference to those experiments, that it is very difficult to keep the temperature of the shaft at precisely the same amount; there is consequently a slight variation in the different experiments; but the general result is as nearly the same as possible under such circumstances.

3384. There is no striking discrepancy?—No.

3385. Whatever discrepancies there are, will they be seen by comparing the results of the tables?—Yes.

3386. *Chairman.*] You found no great difference between the action of the size of the jets?—No, except that the jets were more powerful in the second experiment. The ultimate quantity of air obtained in the second experiment was 234,118 cubic feet per minute; the largest quantity in the first being 207,093 cubic feet per minute. The diagram in Plate VII. will show the result.

Vide Experiments, Appendix to Third Report.

3387. Mr. *Cayley.*] Was the arrangement of the jets the same substantially in both these experiments?—Precisely the same.

3388. And generally speaking throughout your mines?—No, except the Hetton experiments. Figure 8, Plate I., shows the distribution of the jets over the shaft.

Vide Experiments, Appendix to Third Report.

3389. In these two experiments the arrangement of the jets was substantially the same, and the results were the same?—The arrangement was generally the same, and the results were precisely the same, except in one case the jets were three-sixteenths, and in the other four-sixteenths of an inch diameter.

3390. *Chairman.*]

3390. *Chairman.*] There was more power in the last experiment?—Yes; those experiments were made with a view of ascertaining the comparative effect with the natural ventilation, the boiler fires, the steam, and the steam-jets, and necessarily occupied a short time. They were continued a sufficient time, I believe, however, to satisfy every gentleman who was present of their accuracy.

3391. Mr. *Stephenson.*] Had the amount of ventilation, before you brought each experiment to a close, become as nearly as possible uniform?—Yes. Probably it may be as well to allude to a fact which we discovered, which certainly, at first, rather surprised me, notwithstanding I had made a great many experiments on air; that is, the very great rapidity with which the air currents in the mine was increased in velocity.

3392. And therefore it attained its maximum velocity very shortly after the commencement of the experiments?—It did. This was done with a view of testing the accuracy of a statement which was made by Mr. Gurney, in his evidence before the House of Lords Committee in 1849; wherein he stated, in answer to some experiments which had been made by Mr. Thomas John Taylor, that it required a considerable period of time to put the air into motion. In this experiment, (which was witnessed by all the inspectors; in fact, being one of the experiments made on the 13th November, at the same time the other experiments were made,) the temperature of the upcast shaft was reduced to 74°, and the quantity of air passing through the workings was reduced to 80,182 cubic feet per minute. In that state of things the furnaces were lighted, and they were lighted as rapidly as possible, with the view of ascertaining this fact. There were some tar barrels and other substances put on the furnaces, in order to light them as quickly as possible, so as to ascertain the shortest possible time in which the air could be put in motion. It was a very interesting experiment, because it shows within what time you may increase the quantity of air in any mine. The velocity of the air was ascertained by one of Biram's anemometers, placed in the current of air passing towards the furnace C, in Plate I., the anemometer being placed within 50 yards of the furnace. The experiment was commenced by ascertaining the time within which the air passed 1,000 feet. The experiment commenced at 3 h. 48 m. 47 s. At 3 h. 50 m. the anemometer showed that the air had travelled 1,000 feet, viz., in two minutes and three seconds. It was continued up to 3 h. 56 m. 55 s., the anemometer making four revolutions, equal to 4,000 feet, which the air travered in eight minutes three seconds. That was before the furnaces were lighted. Fire was applied to the furnaces at 4 h. 3 m., and at 4 h. 12 m. 58 s. the air traversed 4,000 feet in 4 m. and 3 s.; so that in 10 m. 55 s. after the furnace had been lighted the velocity of the air had been nearly doubled; viz., 4,000 feet in 4 m. 3 s. instead of 8 m. 3 s. The experiment was continued. At 4 h. 16 m. 46 s. the velocity described 4,000 feet in 3 m. 48 s.; and at 4 h. 20 m. 30½ s. it described 4,000 feet in 3 m. and 34 s.; so that in 17 ½ minutes after the fire was applied to the furnaces (because the furnaces did not get into full operation immediately), the air had increased from a velocity of 4,000 feet in 8 m. 3 s. to 4,000 feet in 3 m. and 34 s. That shows the very great facility with which the air can be increased in a mine. The number of currents, and the distance they had to travel, is shown in No. 1, Experiments; and the experiment also showed the very great velocity with the water-gauge increased in power. At four o'clock, before the furnaces were lighted, the water-gauge was 0·45 of an inch; at 4 h. 3 m., when the fire had just been applied to the furnaces, there was an increase of water-gauge; and at 4 h. 23 m. (that is, 20 minutes after the fire had been applied to the furnace) the water-gauge was increased from 0·45 of an inch to 1·75 of an inch; that is, from half an inch, to an inch and three quarters; showing with what very great rapidity, in case of an emergency, the increase of heat in a shaft will more than double the quantity of air, and quadruple the power.

Vide Experiments, Appendix to Third Report.

Vide Appendix to Third Report.

3393. Mr. *Cayley*]. That is, the ventilation being natural in the first instance, and furnace ventilation being in operation afterwards?—Yes.

3394. Supposing the power of the furnace was insufficient, how would you proceed to increase its power?—The working power of the Hetton furnaces, by the experiments in Table VI., is equal to 1·20 water-gauge; and you will observe, that this was acquired in four minutes after the furnaces were lighted. That is the ordinary working power of the Hetton furnaces. By continuing the intensity of firing, in 16 minutes more we increased the power of the water-gauge, and of

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forcing the air round the workings, to 1·75; so that if I wanted to increase the power of the Hetton furnaces from their ordinary working condition of 1·20 water-gauge, I had only to increase the intensity of the furnace, and I could bring it up to 1·75 water-gauge.

3395. Suppose you wanted to increase it to three inches?—That is a water-gauge which is not attainable in practice.

3396. Can you obtain that heat by the furnace system?—I did, in one experiment at Willington, obtain a water-gauge of three inches, but that was not the working power.

3397. Is that about the extent of the power of the furnace?—It is much beyond the extent. I think it would be very wrong for any furnace to be kept in a working state at more than about 1·2 inch. The ordinary working condition of the furnace should be very much below the power to which you could, in case of an emergency, bring it up; therefore, I say, that the regular working of the furnace should never be more than about 1 inch or 1·20 inch; and then, in case of any emergency, when you require an additional quantity of air, you have a power within yourself of increasing that quantity by a very simple and very rapid process; viz., by raising the rarefying power of the furnace.

3398. Simply by intensifying the furnace?—Simply by increasing the intensity of the furnace.

3399. Is that the only reason why you would work up to two or three inches?—Yes.

3400. You wish to have the power at your disposal, in case of an emergency?—Certainly; at least I think it is a judicious mode of working a furnace. The rapidity with which the air could be moved, viz., within 20 minutes of the time the furnace was lighted, the quantity of air being increased from 127,145 cubic feet per minute, to 211,193 cubic feet per minute, shows that in the experiments I have detailed, where two hours were suffered to elapse between one experiment and another, the maximum effect had been acquired in one experiment before it was changed to another. But that there should be no doubt as to the practical test of the two systems, I had the two applied at Hetton Colliery for 12 hours continuously. In Table VI., it will be observed that the jets were applied at six o'clock on the 3d July 1853. This experiment was made with a view of testing what the jets could do for 12 hours; so that there should be no doubt as to the working power of those jets at Hetton Colliery. The jets were applied at six o'clock, and remained until seven o'clock in the evening on the same day. Table VI. in the Appendix shows the results, viz. the total quantity of air obtained by the boiler fires, and the 37 jets, a quarter of an inch diameter, was 159,913 cubic feet per minute, measured as going down the downcast shafts; the water-gauge being 0·8 of an inch, and the pressure of steam 40 lbs. per square inch; the temperature of the shaft being 86° 10 fathoms down, and 90° 65 fathoms down. The quantity of coals consumed during the 12 hours was 18,200 lbs., which is 25·28 lbs. per minute, and 6,400 cubic feet of air for each pound of coals consumed, including the air for the boiler fires.

Vide Experiments, Appendix to Third Report.

3401. What is the sectional area of each jet?—There were 37 jets, of an aggregate area of 1,816 inches; the area of the shaft 153 feet.

3402. That will make about four feet of sectional area to each jet?—A little more than four feet.

3403. Mr. *Stephenson.*] Previously to this experiment, had you ascertained what amount of ventilation would be due to the boiler furnaces alone, when the steam was already blown into the shaft?—Yes, I had for a short period.

3404. Would the difference between the former result and this result give you the amount actually carried round the mine by the force of the jet?—It would.

3405. In Table III., which contains the experiment on 13th November, the boiler fires and steam jet blowing into the shaft, the ventilation due to the fires appears to have been 139,847 cubic feet per minute?—Yes.

3406. In the other experiments where you had the jets, you obtained 159,913 cubic feet per minute?—Yes.

3407. The difference between the two is 20,000?—Yes; but in the former case it will be observed that the boiler fires, and the temperature in the upcast shaft, was only 81° sixty-five fathoms down; whereas in the other it was 86° and 90°.

3408. Does the difference between those two numbers rather exaggerate the effect due to the agency of the steam-jet?—No doubt.

3409. By the amount due to the difference of temperature?—Exactly.

3410. *Chairman.*] At eight o'clock, in the experiments at Table VI., you had only 152,000 cubic inches per minute, and the next hour you rose up to 165,000 cubic feet per minute, and you did not go down again; do you think it is fair to include that experiment at eight o'clock, before the whole power had been developed?—I take the whole as being from eight o'clock.

3411. Mr. *Locke.*] Is it not a remarkable circumstance in that experiment, that the temperature of the upcasts was the same, although the amount of air passing was very different?—Yes, but the result must be taken generally.

3412. At eight o'clock it is the same?—Yes; it is very difficult to ascertain the precise quantity of air at any moment having to be measured in these places.

3413. Mr. *Cayley.*] Were the arrangements of the jets the same in all these experiments?—Yes.

3414. *Chairman.*] Will you give the result of the counter-experiments by the furnace?—As I stated before, the Hetton Colliery is ventilated by three furnaces, one nine feet and two eight feet; and I made an experiment 24 hours with those three furnaces; taking the consumption of coal and the quantity of air in precisely the same way as was done with the steam jets. That will be found in Table V. The average effect of the three furnaces at Hetton was 208,466 cubic feet of air per minute for 24 hours, the water-gauge being 1·2, and the temperature 130° fifty-five fathoms down the shaft. In 24 hours the quantity of coal consumed, was 15,960 lbs. in B, B, furnaces, 11,200 lbs. in C, altogether 27,160 lbs., which is equal to 18·86 lbs. of coal per minute, and 11,066 cubic feet of air per minute for each pound of coal consumed. In this case the velocity of the current was very much greater than the velocity of the current by the steam-jets; and of course the resistance being increased, the consumption of coals is much greater. The water-gauge in this case was at 1·20, and in the other 0·80; therefore the last experiment was against the furnace, as to the quantity of coal for each cubic foot of air. The two furnaces were put out, and one furnace only kept at work, with a view of getting, as nearly as I could, the same circumstances with the furnace as with the jets.

3415. Mr. *Stephenson.*] You mean the same velocity of the current?—The same velocity of the current, and the same quantity of air.

3416. *Chairman.*] And the same pressure, and the same water-gauge?—Yes, as nearly as I could. It is very difficult to obtain precisely the same circumstances; but the experiments in Table VII. and Table VI. are as near as possible similar in all respects. The result of one furnace nine feet wide was 164,750 cubic feet of air per minute, and with the jets 159,913; the water-gauge higher with the furnace. The quantity of coals consumed by the furnace was 7,280 lbs., which is 10·11 lbs. per minute; and 16,320 cubic feet of air per minute for each pound of coal consumed; as against 18,200 lbs. of coal consumed by the jets, 2,528 lbs. per minute, and 6,400 cubic feet of air for each pound of coal; the circumstances being, as nearly as possible, the same during the experiments with the jets as with the furnace, and continued twelve hours. It is rather against the furnace, as the quantity of air with the furnace is greater than the steam jet; and therefore, if there is any balance, it is against the furnace. That is the general result of the experiments at Hetton.

3417. Mr. *Stephenson.*] Will you explain Plate VII.?—It is to show the different resistances of the drag of the air in the mine, and of the resistance in the shaft and over the furnace. The drag of the air was measured by the water-gauge placed at the doors between the upcast and downcast; it is described in Plate II., figure 1.

3418. Mr. *Locke.*] You have explained that the water-gauge only shows a difference in the resistance of the air, in passing through the mine, and before it reaches the furnace or jet?—Yes, the drag of the air around the mine.

3419. Is there any other resistance to the air above the drag of the air, which, in your opinion, is material to be taken into consideration in these experiments?—There is also the resistance of the air in passing over the furnace when the furnace is used, and through the boiler fires when the jets are used, the air being compressed in passing over the furnaces with a view of increasing the intensity of the fire; and then there is also the resistance of the air up the shaft.

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3420. *Chairman.*] Have these been taken into calculation in former experiments?—I think not sufficiently. The resistance over the furnaces depends on the contraction which is given to the air, to increase the intensity of the furnaces, and upon the contraction through the boiler fires; but the resistance up the shaft depends on the velocity of the air up the shaft after it is heated by the furnace, and of course will be regulated by the area of the shaft. Hence shafts of smaller area have a greater resistance than shafts of a larger area. I have not gone into any estimate of the difference; and it has not yet been practically ascertained, what diameter of shaft is the best for ventilation. It is rather a complicated question, and probably it is not necessary to go into it now; but it will be found by these experiments that the resistance up the shaft has a very great effect on the aggregate resistance to the ventilating power.

3421. Mr. *Cayley.*] Is the resistance in the ratio of the size of the air-ways?—I suppose the resistance will be in the ratio of the area of the shaft.

3422. Would the resistance be greater as the area was larger or smaller?—Less, as the area is greater; but another element requires consideration. If you have a large shaft, the velocity of the air in that shaft is less than the velocity of the air in a smaller shaft, the quantity being the same, and therefore in a larger shaft the temperature is comparatively less than in a smaller shaft; and therefore you have to balance between the benefit which is gained by the increase of shaft, and the loss which is occasioned by the diminution of temperature.

3423. Mr. *Locke.*] Have you considered the question as to the relative value of the two?—I have not sufficiently considered it to enable me to speak with any certainty upon it; but I have found a shaft of a smaller area has produced a better comparative effect than a larger one.

3424. Would you therefore assume that the diminution of temperature was rather a serious evil in a large shaft?—It is. There will, of course, be an area of shaft which is the best, under all the circumstances; but that I have not ascertained. The velocity of air up the Tyne main shaft was 2,000 feet per minute. That would operate very seriously in the application of machinery for pumping air up a shaft, looking at the immense velocity at which the air is travelling up the up-cast shaft.

3425. That velocity would be at something like the rate of 2,000 feet per minute?—Yes; and in the application of the steam-jet to the top of the shaft, you are obliged to put cylinders on the steam-jets; and if you put cylinders you lessen the area of the shaft; that very much diminishes the effect of the steam-jets, the velocity being increased to 3,868 feet per minute.

3426. To what experiments do you allude now?—Experiments at Tyne Main.

3427. Experiments which you mean to give the Committee?—Yes; where the jets were placed at the top of the pit.

3428. *Chairman.* Have you anything else to state upon your experiments at Hetton?—I have given a diagram on Plate VII., showing the effect of the resistance of the shaft, and the resistance of the drag of the air round the mine, and by that diagram will be seen the comparative effect of the natural ventilation, of the furnaces, and the steam-jets. Speaking of the drag of air around the workings I would refer to Plate IV., which shows the power required to force certain quantities of air round the mine. It will be seen that at a water-gauge of 0·5 of an inch, 123,463 cubic feet of air per minute were forced round the shaft by natural ventilation; and when the water-gauge was raised to two inches, which was four times the water-gauge, 229,918 cubic feet per minute only was obtained, which is not quite twice the quantity of air for four times the moving power.

3429. Mr. *Stephenson.*] Ought the quantity of air to be as the square root of the water-gauge?—Yes. These were practical experiments which were made to ascertain how far it corresponds with what has been the theory of the resistance of air.

3430. In point of fact you draw the conclusion that the quantity of air forced round ought to be as the square root of the water-gauge?—Yes; and it also shows the necessity of not pressing the velocity of the air to too great an effect, and bears out what I have before stated, that you ought always to keep the furnace at as low a water-gauge as you possibly can, otherwise there is a very great diminution of effect.

3431. Mr. *Cayley*.] There comes in a resisting power?—Yes; the resisting power of the air being as the square of the velocity.

3432. Does not that show that there is a tendency to limit the power?—There is no limit to the power of the furnace more than to any other mechanical power.

3433. If the power of increase can be measured only arithmetically, and the power of resistance is increased geometrically, does not the drag overcome the power?—That depends on the power you use. If you assume a fixed quantity of power, that power increasing, of course, arithmetically, and the resistance increasing geometrically, you come to a balance; but then the stop is in the resistance. You may increase the power in the same ratio as you increase the resistance, and then they go on *pari passu*.

3434. You have never been able to produce more than an effect of two to three inches?—No more.

3435. Mr. *Locke*.] Does your objection to forcing the air beyond a certain height of the water-gauge, apply to all systems of ventilation?—Yes; the objection applies equally to all systems of ventilating power.

3436. Whether it is the steam-jet or the furnace?—Yes.

3437. And the more you increase it, the greater you increase the expense of effecting the ventilation, whatever system may be employed?—Yes; the resistance increasing, the expense of acquiring that velocity is correspondingly increased.

3438. Would you suggest some other mode of increasing ventilation than the means now suggested, if you found that you were arriving at a point at which the ventilation became so expensive as to be almost at its maximum point?—I think that the ventilation by furnace, or by steam-jet, or by mechanical power, should always be kept within certain limits. There is a working limit to the power. If you want to double the quantity of air, it must be obtained by other means, and not by increasing the velocity of the air around the mine. There ought to be a standard of velocity. If you increase the velocity beyond that, you increase it at the expenditure of power and increase of cost.

3439. Do you think it would be better to increase the airways themselves, or to increase the number of shafts?—Either to increase the area of the airways, or the number of shafts, or to split the air so as to diminish the resistance.

3440. In that case, would you also require a larger shaft, in whatever way you split the air?—Probably; but at the Hetton Colliery we have a ventilation of 210,000 cubic feet per minute. We do that at a water-gauge of 1·20. We have in many collieries only 40,000 cubic feet of air per minute, and yet we have the same height of water-gauge.

3441. Does that lead you to suppose that you could, by applying the same means which you have at Hetton, raise the quantity of air to almost any extent, if you adapt your shafts to suit it?—Yes, by an increase of shafts and by a proper arrangement of air courses, and the power applied; but I would not, in any case, use a water-gauge to force the air round the workings more than about 1·20 inch.

3442. You stated that, in your former experiments, the airways travelled at Hetton Colliery amounted to 97 miles?—Yes.

See Summary to Hetton Ventilation, Appendix to Third Report.

3443. Mr. *Baird*.] In measuring the quantity of air in a mine, do you measure the quantity of cold air going down, or the quantity of heated air coming up?—In those experiments the quantity of air going down the downcast shaft has been given.

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APPENDIX.

Appendix, No. 1.

EXPERIMENTS AT SEATON DELAVAL. By *Jude* and Others.

SEATON DELAVAL COLLIERY.

15 June 1853.

MEMORANDA relative to Underground Ventilation. Only ventilating power, "Steam Jets," of which there are 33, each jet being $\frac{5}{16}$ of an inch diameter at orifice. Pressure of steam in boiler 35 lbs. per square inch.

Number of Boilers in use 3.

FIRST EXPERIMENT:

Engine Scale or Fire Drift.

	ft.	in.		ft.	in.
Section	9	6	by	5	8
	9	7	„	5	6
	9	8	„	5	6

Distance, 30 feet.

$$\text{Velocity } \left(\underset{5}{\overset{sec.}{}} + \underset{5\frac{1}{2}}{\overset{sec.}{}} + \underset{5\frac{1}{2}}{\overset{sec.}{}}\right) \div 3 = \overset{sec.}{5.3} \text{ Mean Velocity.}$$

Then

ft.	in.		ft.	in.		ft.	in.		ft.	in.		ft.	in.	inches.
9	6	+	9	7	+	9	8	= 28	9	and $\frac{28}{3}$		9	7	= 115
5	8	+	5	6	+	5	6	= 16	8	and $\frac{16}{3}$		5	7	= 67

$\frac{115 \times 67}{144} = 53.5$ and $\frac{53.5 \times 30 \times 60}{5.3 \text{ sec.}} = 18{,}169$ cubic feet per minute.

Then, by setting open the door, and letting the air have free access to the engine-fires, we have the velocities thus—3½ seconds (mean).

$$\text{Then again } \frac{53.5 \times 30 \times 60}{3\frac{1}{2} \text{ seconds.}} = 27{,}514.$$

Giving an increase, by the door being open, of 9,345 cubic feet.

SECOND EXPERIMENT:

Victoria Way.

	ft.	in.		ft.	in.
Sections	8	7	by	6	4
„	9	0	„	6	2

Distance, 30 feet.

$$\text{Velocity } \left(\underset{5}{\overset{sec.}{}} + \underset{5}{\overset{sec.}{}} + \underset{4\frac{1}{2}}{\overset{sec.}{}} + \underset{4\frac{1}{2}}{\overset{sec.}{}}\right) \div 4 = \overset{sec.}{4.75} \text{ mean velocity.}$$

ft.	in.		ft.	in.		ft.	in.		ft.	in.	inches.
8	7	+	9	0	= 17	7	and $\frac{17}{2}$		8	10	or 106 nearly.
6	4	+	6	2	= 12	6	and $\frac{12}{2}$		6	3	or 75

Then $\frac{\overset{in.}{106} \times \overset{in.}{75}}{144} = 55.20$ and $\frac{\overset{feet}{55.20} \times 30 \times 60}{4.75 \text{ seconds.}} = 20{,}917$ *cub. ft. per minute.*

Appendix, No. 1.

Then again, by setting open the boiler drift-door as before, we have:—

$$\text{Velocity} \left(\begin{matrix} sec. & sec. & sec. \\ 3\frac{1}{2} & + 4 & + 4 \end{matrix} \right) \div 3 = 3.8.$$

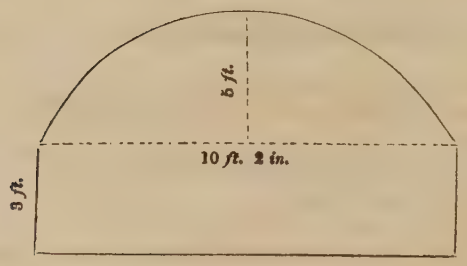
$$\frac{55.20 \times 30 \times 60}{3.8 \text{ seconds.}} = 26{,}147 \text{ cubic feet.}$$

Giving an increase, by the doors being open, of 5,230.

THIRD EXPERIMENT.

Big Arch in Engine Plane.

SECTION.



Distance, 30 feet; mean velocity, 2 seconds.

Here 3 feet = 36 inches.

10 feet 2 inches = 122 inches.

$$\left.\begin{array}{l} \text{Then } \dfrac{36 \times 122}{144} = 30.5 \\ \text{And } \dfrac{10 \times 10 \times .7854}{2} = 39.27 \end{array}\right\} = 69.77 \text{ mean area.} \quad \textit{feet.}$$

$$\text{Thus } \frac{69.77 \times 30 \times 60}{2 \text{ sec.}} = 62{,}793 \text{ cubic feet per minute.}$$

Then, by setting open the boiler fire-doors, the velocities were—

$$\left(\begin{matrix} sec. & sec. & sec. & sec. & sec. \\ 2 + 1\frac{3}{4} + 1\frac{3}{4} + 2 + 1\frac{1}{4} \end{matrix} \right) \div 5 = 1.85 \text{ mean velocity.} \quad \textit{seconds.}$$

$$\text{Here } \frac{69.77 \times 30 \times 60}{1.85 \text{ sec.}} = 67{,}884 \text{ cubic feet per minute.}$$

Giving an increase, by doors being open, of 5,091.

RECAPITULATION.

	Doors Open.		Doors Shut.	Increase.
1. Engine Scale at Fire Drift	27,514 cubic ft. per min.		— 18,169 =	9,345
2. Victoria Way - - -	26,147	,, ,,	— 20,917 =	5,230
3. Engine Plane - - -	67,884	,, ,,	— 62,793 =	5,091
	121,545	,, ,,	— 101,879 =	19,666

Showing an increase, by the fire-drift door being open, of 19,666 cubic feet per minute, or nearly 20 per cent.

Appendix, No. 2.

PAPERS delivered in by Mr. *David Swallow.*

Appendix, No. 2.

RULES and REGULATIONS of the Lancashire and Cheshire Branch of the MINERS' ASSOCIATION.

Established 7 November 1842.

REVISED and Adopted at a County Delegate Meeting, held at the Oddfellows' Arms, *Hurstbrook, Ashton-under-Lyne*, 29th March 1852.

Preface.

THE objects of this society, in conjunction with those of other counties, and in accordance with the General Rules of the Association, shall be to unite all miners of the United Kingdom, with a view to equalise and diminish the hours of labour; to obtain, by strictly legal and peaceable means, the highest possible amount of wages; and to raise from time to time, by subscriptions amongst the members thereof, various stocks or funds for the mutual support of each other in time of need, as there is no security that the members of any society shall receive the benefits set forth in the rules of such society, unless the society is in possession of sufficient funds. Therefore, it is highly desirable that, in accordance with the following rules, each district commence to accumulate funds as speedily as possible. The objects are, furthermore, to improve and elevate the condition of the working miners and their families; to procure for the miners a more healthful atmosphere to work in; to obtain a sufficient number of sub-inspectors to assist the present inspectors, such sub-inspectors to be practical miners of not less than 30 years of age, and to have worked in coal mines at least 15 years; to obtain an Eight Hours' Bill; to have all coals worked by weight and not by measure, and to secure to our children a proper system of education. To effect such purposes we agree to be governed by the following rules and regulations, and such other improvements and additions as may be made from time to time, legally and constitutionally, by properly authorised parties, and according to the rule, as is hereafter made and provided for. This society shall be called and known by the title of "The Lancashire and Cheshire Branch of the Miners' Association of the United Kingdom;" and for the benefit of its members, it shall be divided into districts and lodges, in such numbers as may be deemed necessary and advisable, and in conformity with the rules provided for that purpose. Every district and lodge of this society shall appoint its own officers, and conduct its own business in the manner set forth in the following rules.

All grades of miners are eligible to become members of this society.

Whilst all classes are experiencing the necessity of extended organisation, some individuals are still retaining their old prejudices and narrow-mindedness of sectional unions, and creating prejudice amongst miners whose interests are identical; if one suffers the others must feel it. Not only are the most enlightened trades' unions experiencing the necessity of general union, but Odd Fellows and other benevolent societies have seen the great and urgent necessity of extended organisation. Alas! how frequently does it happen that a man has paid a great number of years into societies, in the fond hope that he would be relieved by its funds in time of sickness and distress; but, when he applies for the amount set forth in the rules, he discovers to his great dismay that sick pay is either greatly reduced, or stopped altogether, whilst other lodges in the same district have no sick at all, and are accumulating funds daily. Yet all are members of one society; all are called by one name; and the rules of the society require that they should call each other brother; but we must confess we can see no brotherly love in it, one starving and the other adding to his funds. It is impossible to enter into this subject in detail here; but, on referring to a table published by the board of management of the sick union of the Preston district of Odd Fellows, Manchester Unity, I find that there two lodges, ending the two years on 9th April 1850 and 1851, have no sick members at all, whilst others have expended 49 *s.* 10 ½ *d.* a member, and the funeral fund besides; whilst each man only paid into the funds of the society in two years 34 *s.* 8 *d.*, leaving the funds minus 15 *s.* 2 ½ *d.* in two years, besides the money paid for funerals, which varied in different lodges for the year ending

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ending 9th April 1851, from 15 *s.* 9 *d.* to nothing at all; but on the whole district it only cost for funerals 4 *s.* per member, and 12 *s.* 8 ½ *d.* for sickness. Although some lodges were so very heavily pressed upon, the whole district added to its funds 7 ½ *d.* a member. If we had room for the tables referred to, they would amply illustrate the folly of sectional unions.* The individuals who are most opposed to a general union acknowledge that the broader basis of any society the better; also that sectional unions cannot do any lasting and permanent good. They will then turn round and say, We know that a general union would be the best if it were honestly carried out and fairly dealt with; and they will ask, Was the last fairly dealt with? To this we reply, No, it was not, it was scandalously abused; but by whom was it abused? The answer is, By the very parties who are now the advocates of sectional unions. Who advocated the crying abuses of the law fund, the travelling committee, &c., with all their abuses; Who were they, do you ask? Why, the sharers of the plunder and partakers of the spoil, and the parties in question. Are there any men who have laboured and done their best to remove those evils? So have we. Are there any parties who intend to keep a sharp look out and see that the same practices are not permitted to occur again? So do we. We are determined to prevent the evils of 1844-5, 6, 7, &c. The same parties, when they see they cannot be permitted to play the old games, are like the old fox in the fable; when he could not get the grapes he turned round and said he would not have them because they were sour.

It is not our wish to impose on either the good sense or the prejudices of any one; at the same time we are in justice bound to remark that many who, through ignorance, were opposed to our views, are now members of our society, and are its most zealous advocates and constant supporters; many, since the establishment of our society, having both seen and experienced the beneficial results of our system, have acknowledged its superiority over any other previous society of miners with which they had been connected.

We hope no prejudices will arise in the breast of any one from the many unsuccessful attempts to establish a permanent society amongst miners, since those failures only tend to point out the errors that have thwarted the good intentions of their founders and supporters.

That a society ought to exist amongst miners we think few will deny, and for this purpose we fondly hope that every miner will see it his duty and interest to come forward and join us.

A few there may be whose contracted hearts refuse to expand with benevolence towards a brother miner in distress, who consider themselves in permanent situations, and think that they will never stand in need of the helping hand of others. We would only call upon such to bring to their recollections how many instances have come within the sphere of their own observation of individuals, lodges, and districts who have thought themselves secure, and yet have fallen when there was no one to help. We have no other end in view than a wish to see a permanent society established, and funds raised adequate to withstand the inclement blasts of adversity and oppression, and that its members may outvie those of similar institutions, and their children have occasion to bless the exertions of their forefathers.

Rules.

How County Meeting to be held.

First Rule. That the county meeting be held at such stated times and periods as may be deemed necessary and agreed upon by the delegates, and each county meeting shall have the power of fixing where it shall next be held; but no meeting shall have the power of fixing more than the next succeeding meeting.

Duties of Delegates.

2. That each district shall appoint one or two delegates to attend each county meeting, whose business shall be to transact all the general business of the society in connexion with the two counties, in the name of and for the districts they represent; such as electing officers and agents, fixing the rate of wages, appointing the routes of the agents, taking an account of their labours, fixing the levy for each member to pay at the next county meeting, according to the 14th rule, making such rules from time to time as may be deemed necessary, according to the provisions of the last rule, and in accordance with the spirit and meaning of these rules; to inquire into the state of the markets and stocks of coal in each district, average wages of each colliery in each district, the state of ventilation in each mine; to order petitions to Parliament for the appointment of sub-inspectors of mines, for an eight hours' Bill, for all coals to be worked by weight and not by measure, to get a proper system of education for the miners' children, or any other matter connected with the welfare of the miners; to take cognizance of any proposed alteration of wages in any district, to devise plans

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* *See* Lectures on Friendly Societies, their History, Progress, Prospects, and Utility, 1851, by Mr. Charles Hardwick. Sold by all booksellers.

plans and means of preventing reductions of wages, if possible; to have power to order statements to be sent to the masters in those districts where this society extends, soliciting an advance of wages at proper times and seasons, and to do such other matter or thing as may be deemed necessary to promote the interests of the miners generally.

Duties of President.

3. That the county meeting shall be governed by a president (and vice-president if necessary). The president shall be elected either from the delegates then present or from among the officials, at the discretion of the delegates, to retain office three months. The duty of the president shall be to preside over the meeting to preserve order, and to see that the discussions are conducted according to the usual rules of debate. The proposer of any motion to be allowed to speak 10 minutes upon his proposition, if he requires to do so; and each delegate five minutes. The officials to be allowed to speak upon any motion, and to give their advice freely upon any subject; to be governed by the same rules of debate as the delegates, but not to vote, move, or second any resolution. No one to be allowed to speak twice until every one present has had an opportunity of speaking once on the subject, if they choose. The order of speaking to go the sun way about. Any one being out of order and disobeying the chairman, when called to order, shall be fined 1*d.* for each offence.

Duties of Financial Secretary.

4. There shall be a financial secretary elected by the delegates at the county meeting, who shall be retained in office so long as he gives general satisfaction. He shall furnish quarterly, and oftener, if necessary, and ordered to do so by the county meeting, an account clearly and accurately setting forth the income and expenditure of both the expense-fund and victim-fund separately. He shall keep his books and papers in such form and manner as the delegates may order. He shall receive the sum of 10*s.* per fortnight for his wages; if the county meeting lasts two days, he shall be paid one day's wages extra. He is to be paid his coach fare to the county meeting and home again, over and above his wages.

Duties of the Treasurer.

5. The treasurer to have 5*s.* per fortnight; if more than one day at the county meeting, he shall be paid extra, and also be paid extra for any other work that he may do besides his office of treasurership, at the same rate that other people are paid; to be paid coach fare same as secretary, and to be governed by the same rules. The duties of the treasurer shall be to receive all the moneys of this society, and shall pay them according to the orders of the county meeting, and not otherwise. All moneys paid without the sanction of the county meeting shall be refunded. He shall give such security for the moneys in his hands as the society may deem proper.

Duties of Corresponding Secretary.

6. The corresponding secretary shall be elected as the other officers are, and subject to the same rules. His duties shall be to keep up a correspondence with Members of Parliament and other parties on the subject of a short-time Bill, getting coals by weight, appointing sub-inspectors of mines, education for miners' children; to correspond with other counties, to write letters in newspapers, and answer all letters on the business of the society. Either the financial secretary, treasurer, or registrar may be elected to this office if the majority think proper; or any other individual may, not holding any other office, at the discretion of the delegates. He shall be paid such sum for his labour as a majority of delegates may deem proper.

Duties of Registrar.

7. That a registrar be appointed, to be governed by the same rules and conditions as the other officers, whose duties shall be to register every member's name and contributions in a book kept for that purpose. Every lodge secretary shall forward, once per month, in a book or paper provided for that purpose, the amount of subscriptions paid by each individual for county fund and victim fund separately, which sum shall be correctly entered in the book, so that the delegates at the county Board can tell when an individual who is proposed at the county Board is entitled to victim pay, and whether he is a legal member or not, as a great number of persons have received victim pay on former occasions who were not entitled to it. Any of the officers named in the three last rules either may or may not be elected to act as registrar, at the discretion of the delegates; to be paid for his labour according to his work, the delegates to fix the rate of wages for such work.

County Fund and Victim Fund to be kept Separate.

8. That the general-fund money and victim-fund money shall be entered in the secretary's and registrar's books distinctly and separately; the income and expenditure shall also be published separately in the balance-sheet, and the secretary shall give to each delegate a receipt for the moneys paid into the hands of the treasurer, such receipt to set forth how much money has been paid to each fund. The county-fund levy at no time to exceed one penny per week.

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Election of Agents, &c.

9. The county meeting shall elect such number of agents from time to time as to them shall seem needful, for the purpose of advocating the interests of the society; and they, like the other officers, shall be entirely under the control of the county meeting, and shall visit such districts as they are ordered and appointed to, and hold meetings, and attend to such other matters as may be needful. That no person shall for the future be elected as agent, or to any other office in this society, unless he has had at least 10 years practical experience as a miner, so as to be able to illustrate and explain the grievances in a proper and intelligible manner.

Slander.

10. That any member slandering or impugning the character of any agent or other officer of this society, without just cause, shall be fined two shillings for each offence. Officers or agents proved guilty of the above-named offence shall be liable to the above-named penalty.

Time before entitled to Benefits.

11. That no person be entitled to any support from the funds of this society until he has been a member of the same not less than eight weeks, and must have paid up all dues and demands to the lodge, district, and general fund, except those who may be discharged for becoming members of this society, going on any deputation, delegation, or advocating the principles of the society, or attending as delegate at any meeting; provided that the person so getting discharged for any of the above-named offences has been authorised by any properly authorised parties to perform such acts. *N.B.*—No person will be entitled to the benefits of this rule who has not paid at least once before he gets discharged, or notice of his discharge. Men will not be supported under the provisions of this rule for frivolous things of any sort; if they leave their work under any other conditions than according to the 12th and 13th rules, they must take the responsibility upon themselves.

Strikes.

12. That no colliery or pit set of men, or any portion of a pit set of men, shall be permitted to stop work or turn out without the consent of five-sixths of such pit or colliery. When five-sixths of the members at any pit or colliery shall have come to a decision that they have a just cause to cease work, they must call, or else cause the district secretary to call, a special general meeting of the district, if the matter should be of urgent importance that it cannot lay over until the regular district meeting, to submit the grievance of such pit or colliery, along with the decision the men have come to upon the matter; the district meeting to enter fully into the subject, and, if it be thought desirable to have arbitration to appoint the same from some members working in the same mine at any colliery either in their own or neighbouring districts; also to make what inquiry and investigation they think proper and advisable; and if after a full and fair investigation the district be of opinion that it is a fair case to send to the county meeting, then they must forward it there, with a full explanation, so that the delegates may take it back to the districts, and bring a decision to the next county meeting whether the men must cease work or not. If after it has been before all the districts, the majority are of opinion that it is a just case in which to cease work, then the men so stopped according to the orders of the board, shall be supported at the same rate as other victims, from the general victim fund, levied and paid for such purposes, in the same manner and on the same terms and conditions as other victims are paid as set forth in the rules. But if after a full, fair, and impartial investigation, the judgment of the county meeting should be against the decision of the men in the matter in question, and the men should stop or cease work in opposition to such decision, then they shall not receive any support from the general victim fund, and must take the responsibility on themselves. No pit set, or any portion of a pit set of men, nor colliery, will be allowed to turn out by this board until they have got 10*s.* per man in their funds, and boys in proportion.

Instructions and Rules for Persons becoming Victims.

13. That members who have paid not less than eight weeks' contributions, and are clear on the book, shall receive an equal share of victim pay along with the other victims, from the general victim fund, in accordance with the following regulations: If a man's life be in positive danger, either from explosions, black-damp, want of props, sudden inundations of water, or bad ropes, he shall be permitted to cease work immediately, if he thinks proper; but be it therefore clearly and distinctly understood, that no man will be permitted to leave his work on account of bad place, alteration of system of working, or any of the thousand-and-one frivolous things that have been urged on former occasions, until he has complied with the following orders: as soon as a free member has a real grievance to complain of, before he leaves his work he shall go to the secretary of his colliery or pit and lay the case before him, who shall call a meeting of the members of such pit or lodge, and they shall have full power to make a proper and searching inquiry into the whole affair; and if the lodge, or as many members as can be got together after proper notice, think

think that it is a fit case to go before the district, then the delegate to the next district meeting must take it there: and if the districts think that it is a fit case for the county board, they must send it in a proper manner, and all particulars along with it; and if the county board sanction it, then the person shall be permitted to cease work and have support at the same rate as other victims. If either the lodge, district, or the county are of opinion that the matter can be settled by arbitration, they are hereby empowered and instructed to appoint the same, on the same terms and conditions as are set forth in the 12th rule, in regard to strikes.

Amount of Contributions, and how used.

14. That it is highly desirable that each district should begin to accumulate funds as soon as possible, as there is no guarantee nor security for any member of any society without adequate funds; therefore it is deemed advisable that the members of this society should pay 6 *d.* per week, or 1 *s.* per fortnight, during the present year, to be disposed of as follows:—To be added to the funds at home, 5 *d.*; general fund, not to exceed 2 *d.*; victim fund, at county board, 2 *d.*; lodge and district expenses, 1 *d.* If 2 *d.* per fortnight more than meets the demands of the general fund, the delegates shall have power of reducing the levy to a proper amount. The delegates at the county meeting shall not have the power of raising the levy at such meeting, until the second county meeting, after a motion has been made to that effect. When a motion is made at the county meeting for an advance in the levies, it shall go back to all the districts and lodges; general meetings must be called to consider the propriety of granting it or not; and all votes for raising the levy at county board must be taken by proxy, 28 days after the motion is made, so that all parties can have the whole matter laid before them, and, if they choose, have a voice and vote in it. *N.B.*—All money for ale and liquors must be paid over and above the 1 *s.* per fortnight.

Entrance Money, &c.

15. That any person becoming a member of this society must pay the same amount for entrance money as the members have in the funds per man, one fortnight's contributions, and 2 *d.* for a copy of these rules; the above law to be in operation only during the year 1852. All persons entering after the close of the present year must pay a premium of 3 *d.* per shilling, besides the sums named above; each district to charge as much more than the above-named sums as they may deem wise and prudent, to be added to their own funds at home, which funds are to be deposited in some safe and secure bank, in the names of three trustees, to be chosen by the men themselves. It is very desirable that one of the officers of the society should be chosen as one of the trustees, so as to prevent the money from being drawn out for any other purpose than that for which it was contributed; the district to have the full control of the funds, where they shall be deposited, and how disposed of, at all times. When any money is wanted out of the bank, the three trustees shall sign a proper cheque for the amount, and at least one of them shall accompany to the bank the person who is authorised by the district to receive the money, so that he may be a witness to what is transacted.

Victims, how paid.

16. That victims of every district shall be paid in such form and manner as the delegates at the county board may deem proper. They shall send the victims' pay either by the delegate from the district, or by one of the officers, or by any other delegate or member from any other district, or by post-office order, as to the delegates may seem wise and prudent; but the victims shall be paid at least once in 12 weeks by some other person than by their own district officers. Every victim's name shall be sent to the county board every fortnight, and shall be published once every eight weeks, with the whole time they have been victims, the amount of money received during the eight weeks, and the whole amount since they became a victim, from both county and districts. All victims, residing within three miles of the place where the county meeting is held, shall fetch their own money from that meeting, which money shall be paid by the financial secretary or treasurer, either in the presence of one of the other officers or a delegate or other person from a neighbouring district. Each victim to draw his own money, except in the case of boys who are members' sons, when the father will be permitted to draw for the whole family. If a person be away from home in search of work, he must send a letter, or else leave a written statement, authorizing either his wife or other member of his family to draw his pay; any person going away from home and wanting his pay forwarding to him, must send a note to the county meeting, signed by some district lodge secretary, to certify that he is not working. That no victim receive more than 13 weeks' pay in succession, except in the case of a strike; if any one is victimized at the termination of a strike, the 13 weeks to commence from the termination of such strike.

Victims' Contributions when Sick, &c.

17. That members who during the time they are victims may become sick or lame, or be playing them, shall only pay general fund and district money.

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Arrears and Re-entrance.

18. Any member allowing his arrears to exceed eight weeks' contributions shall not be entitled to any support from the funds of this society until he has paid his arrears and four weeks have expired from the time of clearing himself on the books; any one in arrear may, at their own option, either pay up their arrears according to this rule, or re-enter as new members, according to rule 15.

Restriction.

19. That as far as it may be practicable the system of restriction shall be acted upon; and all officers of this society shall at the various public district, or other meetings of the society, urge upon the men generally the necessity of acting in accordance therewith, by showing them the good that will necessarily follow from their not sending too many coals into the market.

Boasting about Work, telling Tales, &c.

20. That if any member of this society shall, in a boasting or swaggering manner, tell other people how much money he has earned in a short time (which has too often been the case, and proved very injurious to the coal-miners), on just proof before his lodge, he shall be fined 2 *s.*, which, if not paid within one month, shall be added to his contributions, and put down as arrears.

Victims to meet every other Day.

21. That every member receiving support from the funds of this society shall attend at a certain place every other day (with the exception of Sunday) to enter his name in a book kept for that purpose; the districts to have power of fixing the place and time of meeting. Any victim not attending at the proper time without a lawful reason, shall forfeit one day's pay. Every victim shall, when ordered by any of the recognised officers of this society, do any work that they may require them to do, providing they are qualified to do such work, such as posting bills, warning meetings, getting petitions signed, &c. Any victim refusing to obey such orders shall be fined 1 *s.* 8 *d.*; but the officer shall sign him a certificate that he has done such work, and he shall receive 1 *d.* per mile to defray his travelling expenses, from the county board. Lodges and districts to have the same power as officers over victims.

Frauds.

22. That any member who may fraudulently draw or misapply any money belonging to this society, shall either refund the same, or be prosecuted by the parties so defrauded; the lodge, or district, or county, if they agree to let him refund it, shall determine what sum he shall refund per fortnight.

Ballot.

23. That all votes be taken by a show of hands at the county or district meetings, unless some one delegate desire the ballot; and if any delegate desires the ballot he shall have the power of claiming it; and when it is taken upon any subject of importance, the votes must be recorded, so that each district may see if their representative voted according to their instructions.

Clearances.

24. That clearances be provided by the county board, and supplied to the districts; so that when a member is necessitated to remove from one county to another, or from one district to another, or from one lodge to another, he shall draw a clearance from the lodge he belongs, and must pay all dues and demands up to such lodge for his clearance, and present the same to the lodge belonging to the colliery he goes to work at, within one month after commencing work, or be fined 2 *s.* to the lodge for such neglect. All clearances to be duly stamped with the district seal, and none others to be considered genuine.

Appeal.

25. Any member being dissatisfied with the decision of his lodge or district, may appeal to the county board, the decision of which shall be final.

To be divided into Districts and Lodges.

26. That the two counties shall remain as at present, divided into sub-districts; each district to elect a sub-secretary and sub-treasurer, whose business shall be to keep the accounts of the district to which they may belong, and to transmit the county levy to each county meeting, for delivery to the county treasurer, and the items to the county secretary, for insertion in the county books. All district officers to be paid in such a manner as the districts may think proper.

Government of Districts and Lodges.

27. That districts shall have power to elect their own officers for their own government, and to make their own bye-laws; but all bye-laws to be strictly in accordance with these general laws.

Propositions

Propositions for County Meeting.

28. That no business be entertained by the county delegate meeting, unless a proposition in writing, signed by the district secretary, and stamped with the district seal or stamp, be given to the chairman, certifying that such business has been duly investigated by the district from which it emanated, and a majority of the members of such district record their opinions that such business should be decided at the county meeting.

Lodges leaving one District to join another.

29. That districts shall be composed of two or more lodges, as most convenient. Any lodge desirous of leaving one district to join another must give six weeks' notice to the district they belong to of their intention to do so, and must pay up all dues and demands to the said district, according to rule; then the district secretary shall sign them a certificate of their having paid up all dues and demands to the district they are leaving; but if, after obtaining a certificate, the district they intend to join should refuse to have them, the district from which they received their certificate shall take them back again.

Dividing of Funds.

30. That no lodge or district belonging to this branch of the Miners' Association shall be broken up so long as there are three members true to each other in such lodge or district.

Arrears.

31. That any member being eight weeks in arrears shall not be allowed to vote upon any subject connected with this society.

Violation of Laws of Land.

32. That this association will not defend or support any member who shall in any way violate the laws of the country.

Victims not to receive Support, if they refuse to Work at a lawful Place.

33. That if any brother miner can find any victim or victims work, and they refuse to work, such victim or victims shall not receive any more victim pay.

Contributions of Members not in full Work.

34. That those who only work six days in the fortnight shall pay one penny for general fund, and half of the regular fortnightly levy to the lodge, district, county, and victim funds besides; but if they work eight days, they shall pay a full fortnight's levy; if they play the whole fortnight they shall only pay the district and county levy.

Alteration of Laws.

35. That these laws shall not be altered or rescinded, or new ones made, without giving one month's notice to the county secretary, who shall inform all the districts of the proposed change, so that each district and lodge may have time to consider such alteration or new law, give their calm and deliberate opinion thereon, and vote accordingly.

Appendix, No. 3.

PAPER delivered in by Mr. *W. Gray.*

Steam Jet Ventilation.

Appendix, No. 3.

The Morfa was worked in 1849 with only one pit, divided by 3-inch plank brattice, into winding shaft on one side and pumping shaft on the other side; winding shaft was the down cast of 50 feet area; pumping shaft the upcast of 25 feet area: making an allowance for pumps, rods, beams, &c., the upcast would not exceed 18 feet area. The ventilation was worked by high-pressure steam, a culvert leading from the upcast to a stack 60 feet high, with 16 feet area at the top, with the jet pipes 8 feet from the bottom of the stack, 75 jets of $\frac{1}{8}$-inch square, worked by two Cornish boilers 30 feet long by 6 feet diameter, burning three tons of coal per 24 hours, steam worked up 50 lbs. per inch pressure; and according to Biram's anemometer, measured—

19 December 1849 - - -	11,600 feet per minute.
30 December 1849 - - -	13,104 feet per minute.
17 February 1850 - - -	14,300 feet per minute.

Averaging about 13,000 feet per minute; this plan of applying the steam was abandoned.

To apply the blast pipes, a chamber was built 10 feet high, with sufficient area for 35 blast pipes 10 feet long, 5 inches diameter, the bottom part coned out to 10 inches diameter at the bottom or receiving end, 35 jet tubes 12 inches long served perpendicular into the horizontal branch pipes, and each jet reaching 12 inches up the blast pipes, and about two inches above the cone, or two inches into the parallel part of the blast pipe; 18 of these jet tubes were $\frac{3}{16}$-inch area and 17 tubes $\frac{1}{8}$-inch area, worked from the same boilers at 50 lbs. pressure per square inch, and burning three tons of coal per 24 hours, and measuring according to Biram's anemometer—

20 June 1850 - - - - -	19,000 feet per minute.
1 July 1850 - - - - -	18,000 feet per minute.
14 September 1850 - - - -	21,300 feet per minute.

Averaging about 19,000 feet per minute, this gave us an increase of 6,000 feet per minute over the jets merely going into the stack. The air was split into four divisions; average length of air course 1,300 yards of about 36 feet area each, which is about 4,077 feet of air per minute for one lb. of coal consumed.

Rules and Regulations to be observed by the Workmen employed at the Morfa Colliery.

More than six men are in no case to ride at one time, and the engine-man is to lessen the speed of the engine to one-half.

The firemen are to enter the colliery every morning at a sufficiently early hour to enable them to try each stall where a man is required to work; and, having done so, to report to the overman the state of the colliery before the arrival of the men. As an additional precaution, should they find any stall dangerous, they are required to fix a signal board, with the words "No person to enter this stall."

The cutter is required to see either the overman or fireman before proceeding to his work. Should the cutter at any time consider that his stall is in a dangerous state, he is at once to leave it, and report the same to the overman.

The onsetter must send all the men and boys up the pit before he leaves the pit bottom.

The bankman must not leave the top of the pit until the onsetter has come to bank.

No cutter or trammer is allowed to use a safety-lamp without its being first examined by the lamp inspector, and then locked, and again re-examined by the overman or fireman.

Should any accident happen to a lamp while in use, by which the oil may be spilt upon the

the gauze, or by which it might in any other way be rendered unsafe, it is immediately to be taken out to the station fixed upon by the overman, and not again used until after having been properly examined by the overman or fireman.

Any cutter, trammer, or workman, on the appearance of fire-damp, is to retreat to a pure atmosphere.

All persons to whom the safety-lamp is entrusted are strictly prohibited from interfering in any way whatever with the lamp, beyond the necessary trimming of the wick with the picker; and the lamp is not to be placed within three feet of the side of the goaf, and not nearer the face of the coal than five feet.

Should any cutter, trammer, or other person, when in charge of a safety-lamp, lose his light, he is to take it to the station fixed upon by the overman, to be relighted; and, when relighted, it is to be examined and locked by the fireman before being again used.

It is particularly requested that any person witnessing improper treatment of the safety-lamp, will give immediate information to the overman in charge of the pit, in order that proper steps may be taken to guard the lives of the workmen employed in the mine.

Smoking is not allowed in any part of the mine; and persons found so offending will be liable to a fine of 10*s.*, or be taken before a magistrate, and the fine to be paid to the informer.

No candle to be taken nearer to the pillar working than the station fixed upon by the overman; and any one found with a lighted candle within that distance will be fined 10*s.*, the fine to be paid to the informer.

On no account is any person to keep a gun or dog of any kind.

No person is to have any description of gins, traps, or nets used for snaring game; and, if found with any, he will be fined 15*s.*

No one not connected with the colliery will be allowed to remain about it, and the time-keeper will be fined 2*s.* 6*d.* for each person so offending.

The workmen that are employed at the colliery are required to keep the direct road, and in nowise to trespass on the land by coming to or going from their work; and if found so trespassing will be either discharged or fined.

Caution to all that are Working in the Pits at the Morfa Colliery.

1. Any person found smoking tobacco, or has in his possession pipes, tubes, cigars, or lucifer matches within these pits will be fined one guinea.

2. All blasting powder to be discharged by the overman or deputies.

3. Any other person in the coal-working district of the colliery discharging blasting powder will be heavily fined.

The plans and section represent the working veins of coal. The principal vein is called the Nine Feet Vein, but generally 11 feet thick, being with a very strong bottom; the top is black shale, two feet thick, which is very soft loose stuff. Upon strata, is a very strong cliff, with lines of rock. This vein generally runs 11 feet thick; seven feet of coal is taken away in the stall until holed at the top, and the top coal brought back.

Average run of air about 3,000 yards.

South Fawr Vein has a very soft bottom; puck very much. Shaley coal mixed through the thill. Pretty good top.

North Fawr Vein has a very fair bottom and top.

The ventilation is carried on by the splitting system.

The air is divided at the pit bottom; one part goes west and ventilates a vein not at work, known as the Four Feet Vein; the next is a main split, one part going north to air South and North Fawr Veins; it there splits again, one part to the South Fawr, and the other part to the North Fawr, both returns are brought into a return drift, and joins the Four Feet return, and keeps the course to the furnace. The other part is taken 300 yards through a stone drift, 70 feet area, and splits east and west. The air has a double run east, or two intakes, and two returns at the highest part of the work by two returns left near the crop with the first pillar left below to support the return, so that any gas flowing from the edge of the goaf as the angle of the vein is generally 20 degrees. No gas can remain in the excavated part, but this support pillar must be taken out eventually, and the whole laid down after no district is left behind.

Three years ago we had an explosion, in which seven men lost their lives. One man since killed by a fall of coal. One with not getting properly into the cage or carriage coming up the pit.

Three at different times on the surface railway. One of these, a stoker on the locomotive; another was run over by the locomotive at night, he being very deaf. The other trying to get on to the train when in motion, and fell under the wagon.

Appendix, No. 3.

Description of Furnace.

The ventilation is by furnace.

The height of the furnace 10 feet under the fire arch, and one foot between fire arch and protection arch, to prevent the upper strata from taking fire.

Breadth of furnace, eight feet; about six inches of masonry on each side of the fire bars, to prevent burning the main arch; reducing the breadth of the fire to seven feet. Length of bars 9 feet 6 inches, making 66½ feet superficial. All the surface cannot be covered with fire, say 60 feet of working space, burning about 2½ tons of coal per 24 hours, producing 68,500 per minute, which is rarefied from 62°, before going on to the furnace, to 163°, 20 feet from the top of the upcast pit. Three-fourths of the air is carried over the furnace, and one-fourth taken into the upcast by a separate drift, generally called the dumb drift. This air joins the hot steam from the underground engine.

Temperature of air before getting into the furnace, 62 degrees.
Temperature of air at the top of furnace, before entering the shaft, 230 degrees.
Temperature at middle shaft, 40 fathoms, 195 degrees.
Temperature at top of upcast shaft, 163 degrees.
Temperature at the bottom of downcast shaft, 58 degrees.
Water-gauge, nine-tenths of an inch, equal to five lbs. per foot.

17,655 feet of air per minute, heated from 62 degrees up to 163 degrees, at the top of the pit, by one lb. of coal.

Steam to work an underground engine is brought down the upcast pit from a boiler at surface; this steam to some extent heats the air, and adds to the ventilation.

Section of Pit.

Upcast pit is sunk at a distance of 300 yards, full rise of the measures from the downcast, bearing S. 39 W. Distance under ground is much more by bearing level course 100 yards, and 300 yards full rise, and 100 yards back to the pit, which makes the distance 500 yards to travel from pit to pit. As the vein lies at an angle of from 20 to 30 degrees, the vein at the bottom of downcast pit crops at the gravel before reaching the upcast. The upcast pit cuts the present working Nine Feet Vein between 60 and 70 fathoms from the surface, as shown on section.

The furnace is placed at the depth of about 80 fathoms from the surface; in this vein of coal, about 70 yards from the ingate of upcast pit.

The upcast pit is tubbed off at the depth of 30 fathoms, by fire-bricks and lias lime; the other part is walled up to the tubbing, making the whole distance walled from the furnace area of upcast, 90 feet. Downcast is tubbed off at 20 fathoms from the surface, divided into winding and pumping pits, making 70 feet area in both.

Expenses on Safety Lamps.

To Maintain and keep in Good Repair a sufficient number of Safety Lamps, to work 100,000 tons per Annum.

	£.	s.	d.
220 lamps in daily use on 300 working days per annum, 1,050 gallons of oil, at an average of 2*s.* 10*d.* per gallon	148	5	–
60 new lamps per annum, at 6*s.* 3*d.*	18	15	–
70 lbs. of fine cotton, at 1*s.* 4*d.* per lb.	4	13	4
Wire-gauze, wire for poles, solder, tools, &c.	10	–	–
Wages: to oiling, trimming, and keeping the same in good repair, at 12*s.* per week	31	4	–
To locking lamps, under ground, 300 at 6*d.*	7	10	–
£.	220	7	4

Cost of each light per day, ·80 *d.*

Expenses on Candles.	£.	s.	d.
To maintain 220 lights per day:—180 workmen, averaging 10 hours per day, using six candles each, of 30 to the pound; 40 boys averaging 12 hours per day, using seven candles each of 30 to the pound, equal to 45⅓ per day, at 6*d.* per pound, by allowing 300 working days per annum	340	–	–
Wages to one man for taking charge of these candles, and serving them out, at 12*s.* per week	31	4	–
£.	371	4	–

Cost of each light per day, 1·34*d.*

SECOND

REPORT

FROM THE

SELECT COMMITTEE

ON

ACCIDENTS IN COAL MINES;

WITH THE

MINUTES OF EVIDENCE,

AND

APPENDIX.

Ordered, by The House of Commons, *to be Printed*,
11 *July* 1853.

[*Price* 1 *s.*]

740.

Under 16 *oz.*

THIRD

REPORT

FROM THE

SELECT COMMITTEE

ON

ACCIDENTS IN COAL MINES;

TOGETHER WITH THE

PROCEEDINGS OF THE COMMITTEE,

MINUTES OF EVIDENCE,

APPENDIX AND INDEX.

Ordered, by The House of Commons, *to be Printed,*
26 *July* 1853.

8.o.

Martis, 31° *die Maii*, 1853.

Ordered, That a Select Committee be appointed to inquire into the Causes of the numerous Accidents in Coal Mines, with a view of suggesting the best Means for their Prevention.

Jovis, 2° *die Junii*, 1853.

Committee nominated of,—

Mr. Hutchins.
Mr. Fitzroy.
Mr. Ingham.
Mr. Hussey Vivian.
Mr. Baird.
Mr. Cumming Bruce.
Mr. Cayley.
Colonel Pennant.
Mr. Mostyn.
Mr. Stephenson.
Viscount Goderich.
Mr. Farrer.
Mr. Child.
Mr. H. A. Bruce.
Mr. Cobbett.

Ordered, That the Committee have power to send for Persons, Papers, and Records.

Ordered, That Five be the Quorum of the Committee.

Jovis, 9° *die Junii*, 1853.

Ordered, That Viscount Goderich be discharged from further attendance on the Committee, and that Mr. Locke be added thereto.

Lunæ, 27° *die Junii*, 1853.

Ordered, That the Committee have power to Report the Minutes of Evidence taken before them from time to time to The House.

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THIRD REPORT.

THE SELECT COMMITTEE appointed to inquire into the Causes of the numerous ACCIDENTS IN COAL MINES, with a view of suggesting the best Means for their Prevention, and who were empowered to send for Persons, Papers, and Records, and to Report the Evidence taken before them from time to time to The House,—

HAVE made further progress in the Matters to them referred, and have agreed to Report the Minutes of Evidence taken before them.

26 *July* 1853.

PROCEEDINGS OF THE COMMITTEE.

Lunæ, 13° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Fitzroy.	Mr. Mostyn.
Mr. Hussey Vivian.	Mr. Farrer.
Mr. Baird.	Mr. Childe.
Mr. Cayley.	Mr. Cobbett.
Mr. Stephenson.	Mr. Locke.

Joseph Dickinson, Esq., examined.

[Adjourned until Thursday, at Twelve o'clock.

Jovis, 16° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Hussey Vivian.	Mr. Locke.
Mr. Mostyn.	Mr. Cayley.
Mr. Stephenson.	Mr. Cobbett.
Mr. Fitzroy.	Mr. Farrer.
Mr. Baird.	Mr. H. A. Bruce.

Herbert Francis Mackworth, Esq., examined.

[Adjourned until Tuesday, at Two o'clock.

Martis, 21° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Stephenson.	Mr. Cayley.
Mr. Fitzroy.	Mr. Cobbett.
Mr. Baird.	Mr. Farrer.
Mr. Locke.	Mr. H. A. Bruce.

Herbert Francis Mackworth, Esq., examined.

Joseph Dickinson, Esq., examined.

[Adjourned until Thursday, at Twelve o'clock.

Jovis, 23° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Cayley.	Mr. Fitzroy.
Mr. Ingham.	Mr. Locke.
Mr. Hussey Vivian.	Mr. Farrer
Mr. H. A. Bruce.	Mr. Mostyn.
Mr. Baird.	

Joseph Dickinson, Esq., examined.

Herbert Francis Mackworth, Esq., examined.

Edward Cayley, Esq., examined.

[Adjourned until Monday, at Twelve o'clock.

Lunæ, 27° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. C. Bruce.	Mr. Stephenson.
Mr. Baird.	Mr. Fitzroy.
Mr. Ingham.	Mr. Locke.
Mr. Cobbett.	Mr. Cayley.

Herbert Francis Mackworth, esq., examined.

Mr. *Martin Jude*, examined.

[Adjourned until Thursday, at Twelve o'clock.

Jovis, 30° *die Junii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Cayley.	Mr. Stephenson.
Mr. Cobbett.	Mr. Mostyn.
Mr. Child.	Mr. Fitzroy.
Mr. Locke.	Mr. Hussey Vivian.

Mr. *Martin Jude*, examined.

Mr. *Robert Henderson*, examined.

Ordered, THAT the Minutes of Evidence, up to the 27th instant inclusive, be reported to The House.

[Adjourned until Monday, at Twelve o'clock.

Lunæ, 4° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Fitzroy.	Mr. Stephenson.
Mr. Hussey Vivian.	Mr. Mostyn.
Mr. Baird.	Mr. Cobbett.
Mr. Cayley.	Mr. Locke.

Mr. *David Swallow*, examined.

Mr. *William Gray*, examined.

[Adjourned until Thursday, at Twelve o'clock.

Jovis, 7° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Ingham.	Mr. Mostyn.
Mr. Baird.	Mr. H. A. Bruce.
Mr. Cayley.	Mr. Cobbett.
Mr. Stephenson.	Mr. Locke.

Mr. *Allan Tettlow*, examined.

Nicholas Wood, Esq., examined.

[Adjourned until Monday, at Twelve o'clock.

Lunæ, 11° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Ingham.	Mr. H. A. Bruce.
Mr. Baird.	Mr. Cobbett.
Mr. Cayley.	Mr. Mostyn.
Mr. Stephenson.	Mr. Locke.

Nicholas Wood, Esq., examined.

Ordered, THAT the Minutes of Evidence, up to the 10th instant inclusive, be reported to The House.

[Adjourned until Thursday, at Twelve o'clock.

Jovis, 13° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Child.	Mr. Locke.
Mr. Mostyn.	Mr. Ingham.
Mr. Cayley.	Mr. H. A. Bruce.
Mr. Baird.	Mr. Cobbett.

Nicholas Wood, Esq., examined.

[Adjourned until Monday, at Twelve o'clock.

Jovis, 21° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Ingham.	Mr. Child.
Mr. Baird.	Mr. Cobbett.
Mr. Cayley.	Mr. Locke.

J. Kenyon Blackwell, Esq., examined.

Goldsworthy Gurney, Esq., examined.

[Adjourned until Monday, at Twelve o'clock.

Lunæ, 25° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Cayley.	Mr. Locke.
Mr. Cobbett.	Mr. Baird.
Mr. Ingham.	Mr. H. A. Bruce.

Goldsworthy Gurney, Esq., examined.

Thomas Emerson Forster, Esq., examined.

[Adjourned until To-morrow, at Half-past Twelve o'clock.

Martis, 26° *die Julii*, 1853.

MEMBERS PRESENT:

Mr. HUTCHINS, in the Chair.

Mr. Ingham.	Mr. H. A. Bruce
Mr. Cayley.	Mr. Cobbett.
Mr. Mostyn.	Mr. Locke.

Thomas Emerson Forster, Esq., examined.

Ordered, THAT the Minutes of Evidence up to this date, inclusive, be reported to The House.

[Adjourned *sine die*.

EXPENSES OF WITNESSES.

	£.	s.	d.
Swallow, D.	15	–	–
Jude, M.	14	2	–
Henderson, R.	10	17	–
Swallow, D. (additional)	3	15	–
Henderson, R. (ditto)	3	2	–
Tettlow, A.	19	10	–
Forster, T. E.	20	–	6

LIST OF WITNESSES.

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MINUTES OF EVIDENCE.

Lunæ, 11° *die Julii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. H. A. Bruce.
Mr. Ingham.	Mr. Cobbett.
Mr. Baird.	Mr. Mostyn.
Mr. Cayley.	Mr. Locke.
Mr. Stephenson.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Nicholas Wood, Esq., called in; and further Examined.

N. Wood, Esq.

11 July 1853.

3444. *Chairman.*] AT the last meeting of the Committee, you concluded the statement of your experiments at Hetton Colliery, and were going to detail some experiments at Tyne Main Colliery with the steam jet, without the aid of any other kind of heat?—Yes. I wish, before entering upon that subject, to direct the attention of the Committee to some general results of the Hetton experiments, which are given in Tables 22, 25, and 31. With reference to natural ventilation, I would refer to Tables A and B of the experiments in the Appendix; and with reference to furnace ventilation, to the Tables V. and VII. I have stated in my evidence, that the result of the experiments upon the consumption of coal at Hetton Colliery with three furnaces, was 11,066 cubic feet per minute for each pound of coal, and with one furnace, 16,320 cubic feet per minute for each pound of coal. I have likewise obtained an account of the practical working of the furnace at 17 collieries in the neighbourhood of Newcastle, being the result of an inquiry by Professor Phillips. I have tabulated them in Table C., and the average of the furnaces of 17 collieries is 13,076 cubic feet of air per minute for each pound of coal.—(*The Witness delivered in the same, and also Tables* A. *and* B.)

Vide Experiments, Appendix.

Vide Experiments, Appendix.

3445. Mr. *Locke.*] Do the results of those experiments confirm the evidence which you gave before this Committee on the last day of its sitting?—They do.

3446. The 13,076 cubic feet per minute, is very nearly the average that had been produced by the experiments which you yourself had made?—Yes, the average was 13,693; and the average of 17 furnaces, ascertained by returns from the different collieries by Professor Phillips, gives 13,076 cubic feet per minute. I would refer also to Table III. of the experiments, giving the power of ventilation of furnaces with different depths of shafts, and at temperatures ranging from 32° to 212°; by which Table, knowing the temperature in, and the depth of the shaft, you may ascertain the power of ventilation of a shaft of any depth, ranging from 120 to 1,200 feet.

Vide Experiments, Appendix.

3447. Will you state what is the meaning of the first column, "Temperature"?—Taking the depth of the shaft at 120 feet, at a temperature of 32° for the down-cast weight of air in that shaft, will be 9,710 lbs.; and if the temperature of the up-cast be 150°, the weight of the column is 7,829 lbs.; therefore the difference between the two, is the power of the furnace in that shaft, which will be about 2 lbs. to the square foot; and then taking the area of the shaft, you have a ventilating power of 2 lbs. per square foot, multiplied by the area; and so with any other depth. If you go, in the same line, to a depth of 1,200 feet, you have 97,104 lbs. as the weight of the column of the down-cast, and you have 78,289 lbs. as the weight of the column of the up-cast; the difference being about 19 lbs. per square foot; therefore, for every square foot of area of shaft, the Table gives the ventilating power of a shaft of that depth. I will now state the consumption of coal by furnaces, with a view of showing the practical

N. Wood, Esq.

11 July 1853.

working of Table III. Table V., page 47, shows that with a width of furnaces of 25 feet, the consumption of coal is 18·86 lbs. per minute, or in round numbers, three-quarters of a pound for each foot of width in furnace; the quantity of coal consumed, being of course in the ratio of the width of the furnace. In the experiments, Table VII., one furnace consumed 7,280 lbs. per minute, which is equal to 0·8 lb. for each foot of width of furnace; and I find that as a general rule, with well constructed furnaces, it may be taken as a standard, that a good furnace will consume three-quarters of a pound of coal per minute for each foot of width.

3448. Mr. *Baird.*] Irrespective of the length?—No; the length being about four feet. The length of open grate is generally the same.

3449. At all widths?—Yes. With reference to the working power of that quantity of coal, you will find, on referring to Table V., page 47, that the whole quantity of air was 208,466 cubic feet per minute, and that this was heated from 69° to 130°, or 61°. Multiplying the quantity of air heated by 61°, and dividing it by 18·86 lbs. per minute, gives the cubic feet of air heated one degree with each pound of coal; and that you will find is 674,260 cubic feet of air heated 1° with each pound of coal. In Experiment Table VII., we have 164,750 cubic feet heated 29½° with 10·11 lbs. of coal per minute, which gives 480,724 cubic feet of air heated 1° with each pound of coal, which is less than the former one; but in this experiment the temperature was affected by water falling on the thermometer. In Table C, which I have quoted as the result of 17 furnaces, you will find that the average of the whole was 13,076 cubic feet of air per minute heated from 66° to 108° with each pound of coal; and that gives as the result 547,680 cubic feet of air heated 1° with each pound of coal. I have therefore taken, as a general result, 550,000 cubic feet of air heated 1° with each pound of coal, and that each foot in width of a furnace would consume three-quarters of a pound of coal per minute.

3450. In speaking of a foot of furnace, you mean a furnace four feet long?—Yes.

3451. That would give an area of four feet?—Yes.

3452. Mr. *Baird.*] Did you find that four feet was the best length?—Yes. If it is made longer than four feet, it is very apt to become uncovered with fire on, in the back of the grate, and then the air gets through the bars without heating. I give the above as a practical standard for furnace ventilation. I should observe, that this is only accomplished when the air is made to pass over the furnace, so that all the smoke is consumed; and it is very important in furnace ventilation, that this should be attended to. When a furnace is properly worked, the whole of the coal is entirely consumed, and no smoke whatever goes into the shaft. This is very important; because any unconsumed coal or smoke going into the shaft adds to the weight of the column of air; and in well-worked furnaces, we consequently find that we can get out of the coal the entire heat that it produces; 550,000 cubic feet of air heated 1° with each pound of coal, being a very great practical result. I mention this more particularly, inasmuch as when we have to judge of jet ventilation, where the coal is consumed not by a furnace in this manner, by the air passing over the top of it, but where the air passes underneath the bars, throwing off a great part of the smoke unconsumed, there is a very great loss of fuel between the consumption of coal in a boiler fire and in a well-regulated furnace; I shall afterwards give the result of this. Before leaving the subject of furnace ventilation, I may observe, and the Committee will see, that the power of the furnace depends upon the depth of the shaft; and that a shaft of 600 feet is double the power of one of 300 feet; but in applying the furnace to ventilate deep mines or shafts, we require a higher water-gauge. Taking the example of the Hetton shaft, we find that a water-gauge of two inches is acquired, which the depth of that shaft enables you to do; the quantity of air in Table XX. is 229,918 cubic feet per minute. In a shaft of a fourth of that depth, you would acquire a water-guage of half an inch or one fourth; and that water-guage of half an inch gives by the Table a quantity of air of 123,463 cubic feet per minute; and as the facility of sinking shafts at small depths is greater than at very great depths, we see that with shafts of small depths, even of 50 or 60 fathoms, we get a lower water-gauge, corresponding with the power of the shaft, but amply sufficient for any ventilation required in mines or shafts of smaller depths. The Table XX. on the height of water-gauge, which is given in the Appendix, will show what quantity of air is obtained with the different heights of water-gauge. I find that in several of the shafts in my charge, at small depths, varying from 40 to

to 60 fathoms, the water-gauge is as low as one-third of an inch, and not higher than half an inch; and that with a water-gauge of that magnitude, which a shaft of 40 or 50, or 60 fathoms will easily acquire by a furnace, we get quantities of air varying from 30,000 to 60,000 cubic feet per minute, which is quite sufficient for the ventilation of collieries of that magnitude.

3453. *Chairman.*] When you speak of collieries of that magnitude, you mean with reference to the depth, because of the facility of putting down other shafts, and that it is not impossible that a colliery at 60 yards depth may be of as great a magnitude as a colliery at a depth of 300 fathoms?—If it is, then we must have a comparatively larger area of shaft, or a greater number of them, to produce the same result. In each individual shaft you cannot get the same power as you have in a deeper shaft; but you obtain the same result by a greater number of shafts.

3454. Mr. *Ingham.*] How many acres of working could you ventilate by 50,000 or 60,000 cubic feet of air per minute?—I think you may ventilate a colliery of 1,000 acres, with 50,000 or 60,000 cubic feet of air per minute; and a quantity of coal worked of about 120,000 tons a year.

3455. Mr. *Locke.*] Does not that depend on the thickness of the mine?—Partly, and partly on the quantity of gas.

3456. *Chairman.*] Would that amount of air be sufficient for such an extent of working in the most fiery mines, and under the most unfavourable circumstances?—No, I think not. The most powerfully ventilated colliery under my charge was Tyne Main. There was an immense discharge of gas from the low-main coal; so much so, that on applying a candle at any of the working bords, there was immediately produced a mass of flame throughout the whole of the face of the bord; and with that discharge of gas the mine was ventilated with perfect safety, working with candles, by having a quantity of atmospheric air very much more than sufficient to dilute the quantity of gas. There were two divisions in that colliery: one had 46,000 cubic feet of air per minute, and the other had 54,000 cubic feet of air per minute; and these currents were taken through an extent of about 40 working places. The dilution was so complete, that without any dumb drift to the furnace, and although the working places were not 400 yards from the furnace, the air came to the furnace so diluted that it was perfectly safe, and we never had an accident or explosion.

3457. Mr. *Locke.*] Can you give the Committee an idea of the number of bords?—I think 50.

3458. What is the width of a bord?—Between four and five yards.

3459. And the height?—Six feet.

3460. Mr. *Baird.*] Did you make any calculation as to the quantity of air that was supplied to each man?—I think there would be about 80 hewers in the mine, and probably 50 other people. That gives about 800 cubic feet per minute for each person.

3461. Mr. *Locke.*] In giving the dimensions, you were understood to state that there would be an area equal to about 4,000 or 5,000 feet of what you call open face, at which the men work?—No; about 1,500 square feet of face.

3462. If a greater number of men were at work, or a greater number of bords were opened, would you think it desirable to increase the quantity of air supplied, namely, 100,000 feet?—That quantity was more than sufficient for the purpose.

3463. Does not the safe ventilation of a mine depend, to a great extent, upon the open face of working of coal; and would you not ascertain that fact before you determined upon the quantity of air which ought to be supplied to a mine?—Yes; it depends upon the extent of face which is opened day after day, and that face yielding the gas. After the face is driven forward, there is generally no very great discharge of gas from the pillars.

3464. In point of fact, is not the constant supply of noxious air in a mine very much influenced by the amount of open face where the men are at work?—It is. Except in case of sudden discharges of blowers, it is precisely in the ratio of the quantity of face opened daily.

3465. Therefore that being so, would the deduction you have given the Committee form this result: that a face of work equivalent to about 1,500 square feet of area of fresh working, would be well maintained by a supply of 50,000 or 60,000 cubic feet of air per minute; as, for instance, at Tyne Main?—The quantity at Tyne Main was about 100,000 cubic feet for that area of face.

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3466. Mr. *Baird.*] That was more than sufficient?—It was certainly more than double. It was sufficient in this case, and it certainly would have been much more sufficient in any other case of which I have had any experience. It was the greatest discharge of gas of any colliery that has come under my experience.

3467. Mr. *Locke.*] You think that in that case, one-half the quantity of air would have ventilated the 50 bords?—I think it would with safety.

3468. Can you state the number of men working in that mine?—About 130, including the workmen and putters.

3469. *Chairman.*] Will you now proceed to the experiments at Killingworth Colliery?—At Killingworth the boilers were placed upon the surface. You will find the description in page 49; plate II., figures 2 and 3, show the mode of applying it.

Vide Experiments, Appendix.

3470. Mr. *Cayley.*] Does it state the striking distances?—The boilers were placed on the surface; the steam was carried down the shaft to the bottom of the pit.

3471. Without any cylinders?—In a steam pipe.

3472. One pipe?—One pipe; then it was carried into a receiver at the bottom of the shaft, shown at C, and from that receiver it was carried to the jets. The steam was carried by a pipe ten inches in diameter to a receiver, which is shown in figure 2, plate II., and was then carried in a pipe up the shaft about 30 feet, and so applied as jets, as shown in figure 6. The diameter of the shaft was 14 feet, divided into four divisions, and the jets were applied in one of those divisions, as shown in figure 6, plate II. The experiments that were made are given in Tables IX., X., XI., XII., XIII., and XIV. Table XXI. shows the results as regards the water-gauge, or drag of the air at different velocities. Tables XXIII. and XXVII. show the general result. I should state that part of the experiments which I have mentioned was the application of the jets at the top of the pit. I had the same jets removed to the top of the pit, the boilers and everything being retained as before. That was done with a view of ascertaining the relative effect of jets placed at the bottom of the pit, and jets placed at the top of the pit.

3473. *Chairman.*] Did you take the pressure of steam at the point where it went into the jet in the receiver?—Yes; in the experiment of the jets at the bottom of the pit, the pressure of steam was taken at the boiler on the surface, and at the receiver at the bottom of the pit; and the steam passed into the jets between the boiler and the receiver; so that the pressure of the steam was ascertained correctly.

3474. Mr. *Cayley.*] What was the pressure?—The pressure varied. It was generally 40 lbs.

3475. Mr. *Locke.*] Can you state to the Committee, the amount of air that was extracted, per pound of coal used, in the same way that you gave it in Tables V., VI., and VII., in your former evidence, as the result of the operations of the furnace?—In these experiments, the quantity of coal consumed by the furnace was not ascertained; but it was ascertained by the boilers producing the steam. My object in making those experiments, was not so much with reference to the quantity of coal consumed, as the actual comparative power applied in the two cases. I relied on the consumption of coal upon the experiments which were made at Hetton and at Tyne Main, and not upon the experiments which were made at Killingworth, which could not be very well made satisfactorily. Table XXIII. shows the comparative power of the different modes of ventilation, without reference to the quantity of coal. The natural ventilation produced 12,040 cubic feet per minute, the natural ventilation in this case not being affected by any furnace at all. There had been no furnace in operation in that shaft for more than 20 years, so that the natural ventilation was precisely what the return air made it, when I applied the steam, without the jets in the shaft; and here the steam was entirely free from any smoke or effect of the boiler fires, as it was in the case of Hetton.

3476. What do you mean by applying steam?—The steam was allowed to issue out of the steam-pipe, without passing through jets.

3477. Can you state the dimensions of that steam-pipe?—The pipe going down the shaft was 10 inches in diameter, and the steam issued out of a pipe 6 inches in diameter into the shaft.

3478. Then in point of fact, it was a steam jet of a large size, and the velocity consequently decreased on issuing from that pipe?—Yes.

3479. *Chairman.*] Where was that?—At the bottom of the shaft.

3480. Mr. *Locke.*] Can you state at what speed that steam would issue?—No;

No; I have not ascertained it there. I have ascertained the velocity with which the steam issued from the jets out of the boiler, but not from the large pipe.

3481. Then the column showing 30,472 cubic feet of air per minute, is the column arising from issuing the steam out of a 10-inch pipe contracted into a 6-inch pipe?—Yes; I consider that the ventilation there was accomplished by the heating power of the steam alone in the shaft, and not by any force at all. The natural ventilation was 68°, and the steam raised the temperature of the shaft to 100°; and it was the difference between 68° and 100°, which formed the increased quantity of air, and that gave the quantity of 30,472 cubic feet per minute. Things being in that state, a cock was turned which threw the steam through the jets, instead of going quietly into the shaft; and in that way I expect that I got the mechanical power of the jets correctly; the quantity of steam issuing into the shaft in both experiments being precisely the same. The quantity of air was increased from 30,472 cubic feet per minute to 34,456 cubic feet per minute.

3482. And the temperature was raised 4°?—The temperature was raised 4°, so that the jets in that case, as a mechanical force, gave about 4,000 cubic feet per minute.

3483. Pursuing that experiment further, what is meant by the column which is called "Furnace" alone?—After that was done, I had a furnace (which as I have said had not been lighted for 20 years) lighted, and then applied to the shaft. The furnace was seven feet in width.

3484. That will represent an area of 28 feet?—Yes; and the result of that was, a quantity of air equal to 38,050 cubic feet per minute. I then applied the jets and the steam in addition to the furnace, to show the effect of the jets as an *auxiliary* to the furnace. The experiment between 34,456 cubic feet per minute and 38,050 cubic feet per minute, was the jets as a *substitute* for the furnace; and this experiment was the jets acting as an *auxiliary* to the furnace; and that gave a quantity of 44,630 cubic feet of air per minute, the temperature being raised from 153° to 173°. This result was attained by the effect of the jets producing a more vigorous furnace; the additional 4,000 feet of air going up the shaft, produced a greater draught on the furnace, and raised the temperature from 153° to 173°; so that the 6,000 cubic feet is not entirely attributable to the mechanical force of the jets, but partly to the additional temperature in the shaft.

3485. It appears that the temperature in that case was only raised from 153° to 173°, and that there was an increase in the quantity of air passing of about 6,000 feet; whereas in the preceding experiment, namely, between the jets of steam and the use of the furnace, it appears that it was necessary almost to increase the temperature of the shaft about 50°, namely, from 104° to 153°, and that there was only an increase of 4,000 feet in the use of the furnace, by that large increase of temperature; can you explain how that apparent discrepancy arises?—That is partly owing to the increased water-gauge at the higher velocity; if you look at Plate V., you will see the increase, in one experiment, of the water-gauge. You will observe the effect of the steam acts on a water-gauge 0·55 of an inch and the jets on a water-gauge of 0·70 of an inch, and then the furnace, on a water-gauge of 0·95; but when you come to apply the furnace and jets, it is operating on a water-gauge of an inch and a quarter; so that the quantity of air is diminished in proportion to the increase in the resisting medium; the resisting medium being in the one case at 0·70, and in the other at 1·25.

3486. Would not the water-gauge rise in the last experiment, where you put on the steam jets along with the furnace, by which a great quantity of air was extracted from the mine, and the temperature raised?—The water-gauge rose 0·3 of an inch; and therefore the effect of the furnace and the jets upon the increased water-gauge was less than upon a lower gauge. The resisting power in one case was 1·25, and in the other it was only 0·70. There is, therefore, a correspondingly less increase of effect; and that shows the necessity of keeping the ventilation at a low water-gauge. If you work at a high gauge, the mechanical power has a correspondingly less effect.

3487. According to Table XXIII., the useful effect was increased to the extent of 6,000 feet, by the addition of the jets to the furnace?—Yes.

3488. That increase of 6,000 feet was the result of raising the temperature from 153° to 173°, whilst, according to the preceding column, the increased effect was only 4,000 feet, and the temperature had been raised nearly 50°?—Yes.

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Yes. When the furnace was applied, in addition to the jets and steam, the water-gauge was lower than when the jets and steam was applied in addition to the furnace; and although the increase of temperature was less with the jets and the steam, yet the column in the shaft was lighter filled with steam than with heated air and smoke; so that the same comparative effect does not result.

3489. Do you attribute that discrepancy to the lighter column arising from steam, as compared with that of air?—There is some difference to be attributed to that, and also to the resistance by the increased velocity of the air.

3490. Did you take precautions, in this furnace experiment, to consume the air as thoroughly as you stated it was desirable to do, in the former part of your evidence?—The same precautions, but not so effectually.

3491. Then you think, probably, that in that case, the combustion of the air passing over the furnace was not quite so good as it might have been?—I think it was not quite, although there would not be very much difference. It was an old pit, and the air was brought round a short distance with a view of performing the experiment, the general ventilation of the colliery being at a considerable distance. I do not, however, attribute very much to that effect.

3492. Mr. *Cayley*.] Is it your opinion that the water-gauge is a measure of the power of ventilation?—The water-gauge I think is a correct measure of the drag of the air from the door on which it is placed, until the air returns to the other side of the door.

3493. That is, you state that the water-gauge is a measure of the power of ventilation?—No; it is only the indicator of the resistance of the air around the workings of the mine, from the bottom of the down-shaft to the bottom of the up-cast.

3494. Is not the resistance in some measure proportioned to the pull?—There is another species of resistance, which I explained on the last day; there is a resistance over the furnace, or through the cylinders of the jets, as they may be applied, in addition to the drag of the air.

3495. Of what do you consider the water-gauge to be the measure?—The drag of the air around the workings of the mine; but there is another resistance, which is the resistance of the same air going over the furnace, or through the cylinders of the jets, and up the shaft; and if you speak of the general power of ventilation, you must take into account both those resistances.

3496. What is the greatest disturbance of the water-gauge by the jet in any of your experiments?—That is shown in Tables XX., XXI., and XXII.; and the greatest water-gauge was 1·1 inch; that is shown in Table XXI.

3497. Why was it not greater?—Because the jets had not power to make it greater.

3498. Is it your opinion, that no greater effect can be produced by the jet on the water-gauge than was attained in your experiments?—Not by the jet of the dimensions shown there upon an area of shaft equal to that given.

3499. If any other size could produce a greater effect, why was not that used?—In that case there were three boilers used to produce it.

3500. Then your opinion is, that you obtained the maximum of the steam jet in the way you applied it?—With three boilers as applied.

3501. Mr. *Locke*.] Give the dimension of those boilers?—I think they were 34 feet long, and five feet in diameter.

3502. Can you give the area of the grates in those boilers?—They are what are called flash flues; I give in the experiment the quantity of water evaporated per minute, when the jets were in operation.

3503. Can you state the area of the grates?—The area of the grates was five feet by four feet for each boiler.

3504. Mr. *Cayley*.] You have described various modes of ventilation, natural, furnace, and steam jet; the two former act through the means of the difference in the up-cast and the down-cast?—They do.

3505. Is it a necessary part of the efficiency of the steam jet, that the temperature should be much considered?—Certainly; because if you have a power acting before you apply the jets, you must know what that power amounts to, before you can ascertain what power the jets will give you in addition.

3506. Is it not the province of natural ventilation, or of furnace ventilation, to act through the principle of rarefaction?—Yes.

3507. Is it not the main province of the steam jet to act mechanically?—If the steam jet is placed at the top of the pit, then it acts entirely mechanically; but

but if is placed at the bottom of the pit, then the boiler fires and steam act by rarefaction, in addition to the mechanical force of the jet.

3508. If you produce ventilation by the heat of the boilers or by a furnace, at the same time that you are using the steam jet, and that heat produces a sufficient rarefaction to produce, say, an effect on the water-gauge of two inches, and if you then apply the jet with an insufficient pressure, so as to produce a power beneath that which you have previously obtained, will not the power of the steam jet be a nullity; or in other words, if you apply the steam jet, so as to produce a less power than you are previously applying by the furnace, may you then make it appear that the steam jet is producing no effect under those circumstances?—In all my experience, supposing that a certain amount of ventilation is acquired by the furnace and by the heat of the boiler fires, and then you apply the steam jet, you get a certain amount of mechanical power by that jet; and that is given in the experiments.

3509. Is it not a condition of the steam-jet ventilation that the whole of the column of air, within the shaft, should be lifted?—Yes; the whole depth of the shaft.

3510. And that, in point of fact, instead of rarefaction driving up the air, as it were, through the mine by its lightness from increased rarefaction, the steam jet acts mechanically, by driving the whole column of air before it up the shaft?—Yes; but I beg to refer to Plates X. and XI., No. 3, which will show the action of the jet and the column of air lifted up within the shaft, when the jets were applied at Killingworth. The jets were applied at the bottom of the shaft; and the diagram, No. 3, shows the effect of those jets acting on the column of air in the shaft; and it will be observed that the effect of the jets is to push, as it were, the column of air at a more rapid rate immediately above the jets, and to produce an increased vacuum for a short distance, and then the effect of the jets ceases. Where that diagram is expanded, it shows the effect of the jets acting on the column of air, and that the effect is simply to push the column of air upwards rapidly, immediately above the jets, and above that to increase the density of that column. The effect of the mechanical force of the jets is therefore counteracted by the increased density of the column above; and if you compare No. 2 and No. 3 in those diagrams (the one being the effect of the steam in the shaft before the jets were applied, and the other being the effect after the jets were applied), you will see that the density, being shown by the increased area of those diagrams respectively, is less in the entire column of No. 2 than it is in the entire column of No. 3; therefore the effect of the jets, as I have before stated, is to operate on the air immediately above them, so as to put the air in motion, but in the column above, it increases the density of that column,and so diminishes the effect.

3511. Then you do not believe that the column of the shaft was lifted by the arrangement you made?—The diagram, being the result of experiments, shows the precise amount of lift which was given to the column by the jets.

3512. Was not the pneumatic flower-pot, as it is called, established; that is, that the jet being so disposed, the air was drawn up through the middle, and that there was a retrograde current down on each side?—There was no such thing.

3513. How do you know that?—Because I looked at it; I stood opposite the jets, and I could see the effect of the jets for a certain height above.

3514. There was no retrograde current?—No, not when the velocity of the air in the shaft was considerable.

3515. Do you believe that the steam jet can be made by a proper arrangement, to give a greater amount of disturbance of the water-gauge than you produced?—I think not; I tried it in every way; I tried it with cylinders and without cylinders around it, and I could not devise any other mode of giving it more effective power.

3516. You produced the greatest result you possibly could?—I think I did; and I think that no other person has produced any greater effect.

3517. Did you see the experiments which were tried at the Polytechnic last year?—Yes.

3518. Did you see there that the water-gauge was disturbed to the extent of 15 feet?—Yes; and I think that was strictly in accordance with my experiments.

3519. You have stated that the only effect produced on the water-gauge was 1·1 inch?—Yes; but if you take the comparative area of the shaft, and of the tube which was operated on at the Polytechnic, you will find that the effect of the

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steam power was comparatively the same in both cases. In the one case you have to operate on a shaft 153 feet in area, as at Hetton Colliery, and in the other you operate on a tube, I think, half an inch in area; and of course the effect on the small area must be to increase the water-gauge, the effect being as the relative areas.

3520. Suppose the jets are increased in proportion to the area?—I do not think it is possible to do it practically. If you are to produce the effect of 15 feet of water, you must have the same comparative amount of power as you had in the tube; and if you apply that to 130 feet area, you will find that you would require an immense number of boilers to produce the same relative power.

3521. That is your view?—It is the common sense view, and it is in accordance with every principle of mechanics.

3522. You will admit that there is a correct way and an incorrect way of trying the experiment?—Yes.

3523. Have you the slightest idea that the jets as you arranged them would produce a pull sufficient to overcome the drag of the mine?—They did to a certain extent, as shown by the experiments.

3524. But barely?—To the extent which is shown by the experiments. In the case of Tyne Main, where the jets were placed at the top of the pit without any extraneous power, the effect is shown in Table XVIII.

3525. In what respect did your experiments in the year 1852 differ from your experiments in the year 1849?—I had made no experiments in 1849.

3526. Did not you state in your evidence in 1849 that you had made some experiments?—I stated in my evidence the result of some experiments which had been made at different collieries, but I did not superintend those experiments. I do not think the experiments that I have since made at all militate against those experiments.

3527. Were they made in the same manner?—In 1849, and before the experiments of 1852 were made, there were no experiments dividing the different powers; the others were the aggregate of all the different powers; so that you could not, by the previous experiments, ascertain what was due to the mechanical force of the jet.

3528. To whose experiments did you refer?—Mr. Elliott made some experiments, and some at North Hetton Colliery.

3529. Did you see those experiments?—No; I saw the jets at work, but they were abandoned.

3530. Are all your experiments contained in your pamphlet?—No; I have since made some others; I rather wish to speak of one that was made at South Shields, because, I think, it is interesting and useful.

3531. Was that experiment made at the St. Hilda and Harton Pits?—Yes.

3532. With regard to the experiments which you have stated in your pamphlet, are the data, the principles, and the conclusions correctly stated?—I think so, generally.

3533. Do you abide by the data, principles, and conclusions, as stated in that pamphlet?—Generally; some errors have crept in; I was very much occupied, and they took a vast deal of time; I believe there are some trifling errors, but I believe they do not militate against the principle, or substantially against the result.

3534. Were you able, in the experiments at South Shields, to produce by the jet, the effect which you were unable to produce by the furnace?—The jet was inferior to the furnace. By the jet the quantity of air was 10,500, the natural ventilation 6,750, and by the furnace and jet it was 17,611 cubic feet per minute.

3535. Mr. *Locke*.] What are you quoting from?—From experiments at South Shields, which are contained in Paper (D.), Appendix.

3536. *Chairman*.] When you say that 10,500 cubic feet of air per minute were produced by the steam jet, do you mean the steam jet alone working at the bottom of the pit, without the aid of any rarefaction whatever, under the same circumstances?—The jets, in that case, were placed at the top of the pit.

3537. Mr. *Cayley*.] Is it true that the St. Hilda Pit was in such a fiery state, that between the St. Hilda and the Harton Pit the mine became in a very inflammable state, and that you could not get rid of that noxious state of the mine until the steam jet was applied?—The St. Hilda Pit was under repair in the shaft, and the ventilation had been suspended in that pit for several months; it was necessary to take the tubbing out of the pit; and the ventilation was suspended to prepare for a permanent up-cast shaft. During that time it filled with gas.

The

The Harton Pit was always in a perfect state of ventilation, being independent of Hilda. After the tubbing and the shaft had been put right in the Hilda Pit, it was necessary to resume the ventilation; and I applied the steam jet with a view of clearing the pit of fire-damp, finding it dangerous to apply a furnace at the bottom of the shaft. The jets were applied, and were the same as shown in figure 2, plate II.; and those jets produced 10,500 cubic feet of air per minute. Finding that the jets were incapable of ventilating the whole of that colliery, I applied fire to the engine-boilers which were down the pit, at a distance of 528 yards from the bottom of the pit.

3538. Why did you resort to the steam jet on that occasion?—Because I could not get to the bottom of the pit to put a fire in; I thought it was not safe to do so.

3539. If the furnace had been lighted, it would have been lighted with gas?—No; not with the requisite care. I brought the fresh air from the Harton Pit to work the furnace, and so made it safe; and the furnace ultimately has been obliged to be resorted to, to clear the pit of the foul air. I could not have applied the furnace, without bringing the fresh air from Harton Pit, which I did not at that time think it advisable to do. I think that the application of the steam jet there was useful and proper; and that to the extent to which it went, it was useful.

3540. Mr. *Locke*.] In any of these experiments, did you make use of the steam jet, after finding that the furnace was insufficient?—The steam jet was applied before the furnace was put in operation.

3541. And that was because you found it was inconvenient to apply the furnace?—Yes.

3542. After you had used the steam jet, did you resort to the furnace?—I did; and I found that the jet was of a power which was useful to a certain extent, but insufficient to clear the pit entirely of bad air.

3543. Then you mean to say, that by the use of the jet, you got 10,500 cubic feet per minute?—Yes.

3544. Can you inform the Committee what amount you afterwards obtained by the use of the furnace, in the same place?—With the furnace and jet 17,611 cubic feet per minute.

3545. Therefore, instead of having applied the jet, because the furnace was inefficient, you used the jet for a certain period, producing the result of 10,500 cubic feet per minute; and afterwards, when you could use the furnace, you obtained the result of 17,611 cubic feet per minute?—I did.

3546. Mr. *Cayley*.] As it was applied by you, you could not obtain a greater power by the steam jet, than you did obtain?—No. Two boilers were applied, and that was as much as the two boilers would do.

3547. Mr. *Locke*.] What is the effect of a jet of steam in a locomotive engine chimney?—It acts entirely mechanically.

3548. Do you know whether altering the condition of the locomotive engine in reference to the size of the chimney, its width, and length, would materially alter the jet of steam so acting?—I believe that the proportions between the area of the jet and the dimensions and length of the chimney have been varied much, and I believe that engineers have now come to some proportion which is the best. I believe that the proportion which I adopted in my experiments, was something like about what is considered to be the best proportion.

3549. Are you also aware, that a large increase of the generative power of engines, would in some measure necessitate an alteration in the size and length of the locomotive chimney?—No doubt.

3550. Do you think that the depth of the shaft bears materially or immaterially on the useful effect of steam used as a jet in a shaft?—It does, very much; I have gone very carefully into the power of the jet in locomotive chimneys; and I think that power, and the effect of it, corresponds precisely with the experiments that I have made in deep shafts, taking into account the resistance of the shafts, and drag of air as compared with the chimney.

3551. You were understood to state, that in the experiments which were made with the jet, you did move the entire body of air in the shaft?—Yes.

3552. And that up to a certain extent, it appeared as if the expansion and the whole body of air was moved?—Yes, the expansion partly, and the effect of the jet partly.

3553. And that its useful effect was diminished, either by the weight of the

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column, or by the friction of the air passing the shaft?—Yes, by the elasticity of the column.

3554. Supposing the shaft to have been only so deep as the point at which the whole column was lifted, and then ceased to have that useful effect, if the issue had taken place at that particular point, would the effect of the steam jet have been much more considerable?—It would, in the proportion of the amount of resistance of the weight of the superior column. In applying it at the top of the pit, no such weight of column is opposed to the power of the jet. The jets were placed in cylinders six feet long, and the whole effect of the mechanical force of the jet was there obtained, without the counteracting resistance of the column above it.

3555. In those cases, at what distance below the mouth of the shaft were the cylinders placed?—Near the top of it.

3556. Ten or 20 feet?—About 20 feet.

3557. Were they placed sufficiently low to allow the column of air to have the full mechanical effect from the steam before it arrived at the top of the shaft?—The mechanical effect of the jet there, was all expended within the cylinders.

3558. Then in your judgment, after escaping through the cylinders, the sooner it escaped into the air at the top of the shaft, the better?—Yes; it acted precisely in the same way as in a locomotive chimney, the jet being at the bottom of the chimney in the one case, and at the bottom of the cylinder in the other.

3559. In the experiments that you have made on the jet, and those which you know to have been made, do you think the application of the jet, whether at the bottom of the shaft, or at the top of the shaft, has been made in a proper and scientific manner?—I think that the experiments I have made, have been so conducted. It was my anxious wish, that the experiments should be made as complete and effectual as possible, and I consulted with every one who I thought knew anything on the subject, as to the mode in which they ought to be conducted. I invited Mr. Gurney to come down to the north, to see the experiments conducted; and I should have been very glad if he had come to make suggestions to me, as to any variation in the mode of conducting them; and if Mr. Gurney will now suggest any different mode of applying the jets, I shall be very glad within the next week or two, to resume the experiments in any way he may think proper.

3560. When the cylinders are used at the top of the shaft, is it one cylinder only, or two or three?—Sixty-one cylinders, six feet long and 11 inches in diameter.

3561. Do those cylinders entirely fill the shaft?—Yes; and all the insterstices around the cylinders were closed, so that the air could only go through the cylinders. Fig. 11, Plate II., shows the mode in which the cylinders were disposed in the shaft.

3562. Do you know that any steam jet experiments have been made by any other parties on a large scale, which have given better results than those which you have yourself obtained?—From all I can learn, the result of experiments which have been made by others corroborates the experiments that I have made.

3563. Have any other persons instituted more extensive experiments than yourself on this subject?—No. I believe Mr. Elliott has made a considerable number of experiments, which he is prepared to give to the Committee. I have not seen an account of those experiments.

3564. Do you know where those experiments were made?—They were made at Lord Londonderry's collieries.

3565. From the answers you have given, are the Committee to take it for granted that although in experiments made in small machines like a locomotive chimney, or a tube at the Polytechnic, or Perkin's steam-gun, you may have obtained great results mechanically, yet that when you apply steam for the purpose of ventilating a coal mine, you do not find that the mechanical effect is at all commensurate to the mechanical effect produced by those small machines?—The comparative effect I consider to be precisely the same. If the result of my experiments at Tyne Main, with 61 cylinders 11 inches in diameter, were compressed into that of one tube, you would find the aggregate result that I obtained, viz., 0·4 inch water-gauge, for 40,258 feet area, brought into an area of half an inch, would produce a higher result than was obtained at the Polytechnic, viz., 32 feet of water-gauge instead of 15 feet.

3566. *Chairman.*]

3566. *Chairman.*] If you were to try an experiment of that kind, the steam would pass through the small cylinder, and there would be no room for air at all, because the steam would fill the cylinder?—Certainly. It would be of no use as a ventilating power. It is a mode of displaying the power of the jet popularly; but when you go into the calculation, you will find that it gives just the same aggregate result as if it was disposed into a water-gauge of 0·4 of an inch.

3567. Mr. *Locke.*] You think that the sum of all the cylinders put together, even on a low water-gauge, would give you a mechanical effect similar to that which you find from the locomotive?—I do say so. It is merely taking the area of all the tubes, and the pressure per inch upon them, and resolving that into a tube of half an inch area, and instead of a water-gauge of 0·4 inch on the aggregate area of the tubes, you get a water-gauge of 32 feet on the single tube 0·5 inch area.

3568. *Chairman.*] Then the general result of all these experiments in your opinion is, that the steam jet is inferior to the furnace ventilation?—It is considered as a substitute for the furnace. It is an expensive and uncertain mode of ventilation.

3569. Mr. *Ingham.*] Do you know in how many collieries in the north it is used as the only mode of ventilation?—I believe it is only used at Seaton Delaval.

3570. Is it not used at South Hetton?—It has been applied at South Hetton, but I do not think it is in use at South Hetton.

3571. At Seaton Delaval, in what portion of the shaft are the jets placed?—At the bottom.

3572. *Chairman.*] In Seaton Delaval there is rarefaction in the boiler fires being below, as well as gas retorts?—I believe so; I have not myself seen it at Seaton Delaval; but the accounts I have read so represent it.

3573. Although it is your opinion that the steam jet is inferior to furnace ventilation, can you conceive circumstances in which the steam jet may be made very useful?—I think that in some cases it may be made useful. It is made extremely useful in the locomotive engine, and it may be made useful in certain cases in collieries. The objection that I have urged was the attempt which was made to induce the mining interests of the kingdom to rely too much upon it, which I think might have produced very serious consequences. It was with that view that I thought it was incumbent upon me to make those experiments. The result of those experiments is, that it may be useful to a certain extent, but that as a substitute for the furnace, or as an auxiliary to the furnace in general mining ventilation, it is both less efficient and more expensive.

3574. Whatever may be your opinion as to the merits of any system of ventilation, either steam jet, or furnace, or mechanical ventilation, you would not recommend this Committee to report to the House, that any particular system of ventilation should be adopted in collieries?—I think that the Committee would do right in leaving the different coal-owners to adopt such a system of ventilation as they may deem advisable. It may be necessary that this Committee should say that mines should be properly and efficiently ventilated; that probably may be a very useful measure; but if this Committee were to lay down any rule, or any recommendation, that the coal-owners should adopt either one or the other of the different methods of ventilation, I think it might have a very injurious effect. It would be best to leave the coal-owners themselves to judge of that. I think that this inquiry, bringing out all the experiments that have been made on the different modes of ventilation, and circulated in the mining districts, will be of very great use, as bringing together a body of facts; but I think that the coal-owners are the proper persons to act upon that information, so as to adopt that system of ventilation, which under all the variety of circumstances may be most useful.

3575. The Legislature merely taking care, through the inspectors, that there is sufficient ventilation to render the collieries as safe as possible?—Yes; I think so.

3576. Supposing that a sufficient quantity of air was by any mode brought into a colliery, do you think that the system has attained its full perfection; or do you think that it is necessary to pay great attention to the capacity and size of the airways?—I think that sufficient attention has not hitherto been paid to the mode of circulating air around the workings; I find that in several districts of the country, the managers of mines are quite ignorant of the principles of

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ventilation, and are acting on principles which my experiments show are not correct.

3577. Have you, before going into this part of the subject, any other observations on the power of the furnace or steam jet?—I will refer to those parts of the experiments where the general results are given. At page 34 (*vide* experiments, Appendix) of my pamphlet, you see the mode of applying the jets at Tyne Main; and at page 77, the particulars of the area of the shaft; and in page 57 the length of air courses. Tables XV. and XVI. show the result of those experiments; and Tables XVII. and XVIII. show the consumption of coals. The result of the latter is shown at Table XXII.; and the general results are shown in Tables XIV. and XXVIII. Then I applied the jets at Norwood, near Ravensworth. The experiments which I had previously made were in deep shafts; I made the experiments at Norwood Colliery in a shaft of moderate depth; the mode of application of these jets is shown in page 61, and the result is shown in page 72. In page 79 you will find the results of the jets placed at the top, and at the bottom of the pit; and in pages 51 and 53, you will find the comparative effect of the jets applied with and without cylinders. At page 90, you will find the comparative results of the jets and furnace as to consumption of coal; in page 91, the result of the jets as a *substitution* for the furnace; and in page 92, the result as an *auxiliary* to the furnace. I will put in a paper of the experiments made at Hilda, to show the effect of clearing the pit of gas by the jets and by the furnace. (*The Witness delivered in the same.*)

Vide Appendix, Paper D.

3578. Mr. *Locke.*] What is the maximum result that you have attained by the use of the steam jet in any of the experiments you have made?—The maximum result at Hetton was 15,099 cubic feet per minute; and at Killingworth, 10,490 cubic feet per minute, the jets being placed at the bottom of the pit; and at Tyne Main 12,400 cubic feet per minute, the jets being placed at the top of the pit.

3579. Were the steam-boilers in all these cases at the top of the pit?—At Hetton at the bottom, and at Killingworth and Tyne Main at the top of the pit.

3580. Is there anything to be deducted from these results, for what may be called the natural ventilation?—There is at Hetton and at Killingworth, the increased heat produced by the boiler fires and steam acting on the air in the shaft. At Tyne Main there was not; I have come to the conclusion, that about 12,000 cubic feet per minute is the maximum effect with the jets; the evaporation of water being as given in the experiments, or with two boilers.

3581. Were the sizes of the boilers which were used in these three collieries much the same, or were they different?—At Hetton there were two boilers; at Killingworth there were three boilers; at Tyne Main there were two boilers; the dimensions were much the same; they were generally 30 feet long, and five feet in diameter.

3582. *Chairman.*] You have been comparing the effect of the steam jet through locomotive tubes with furnace ventilation; in the one case you raise the steam to about 100 lbs. to the inch, while in the other experiment you only got the steam to a pressure of about 50 lbs. to the inch. Supposing you had had boilers which would have enabled you to have raised the steam up to the pressure of 100 lbs. to the inch, do not you think that the mechanical power of the steam jet would have been greatly increased?—The mechanical power of the jets would depend on the velocity with which the steam issued from the jets and the quantity. At page 28 of my pamphlet, you will find the view I have taken of it, which I believe is correct: viz., "The velocity with which elastic fluids rush into a vacuum, is that which a heavy body will acquire by falling through a homogeneous column, equal to the height due to the pressure or elasticity of the fluid; and the velocity with which a fluid of one degree of elasticity will rush into an atmosphere of a different degree of elasticity, is that which a heavy body will acquire by falling through a homogeneous column equal to the height due to the pressure, or difference of degrees of elasticities of the two fluids." That would give the same velocity at a pressure of 50 lbs. and 100 lbs. into a vacuum. I give, a little further on, a formula of the application of that principle to the case in question, where the steam does not issue into the vacuum, but where it issues into the atmosphere; and it will be seen (page 29, line 26), that with a pressure of 40 lbs., it issues about 1080.6 feet per second; and at a pressure of 50 lbs., it issues 1088.4 feet per second, being not eight feet per second more than for steam at 50 lbs., than at 40 lbs. pressure per square inch.

3583. Mr.

3583. Mr. *Stephenson.*] In point of fact, is not the only alteration which is produced, the density of the steam, and not the velocity of the jet?—The difference is in the density or quantity of the steam, and not the velocity of the jet.

3584. Mr. *Locke.*] Do you mean to state that the velocity of steam issuing from the jet at 100 lbs. pressure, is the same as the velocity at which it issues at 50 lbs. pressure?—Yes, if it issues into a vacuum. If you can double the density, you get double the quantity of steam issuing through the jet in the same time; but it only issues with the same velocity; and therefore, the initial mechanical effect of the jet will not be increased by an increase of density. The velocity being the same, the density is doubled; but the initial effect of the jet being that with which the velocity of the steam impinges on the air, the initial mechanical effect will be the same, whatever may be the pressure of steam. But you have steam of double the density; hence the aggregate effect by the greater density, but not by the velocity.

3585. Mr. *Ingham.*] In deciding the question of the expediency of ventilating a colliery by steam jet, why should you look at the result, deducting the effect of the boiler in increasing the expansion of the air?—The question in that case is, whether by the same consumption of coal, you get the same effect. The effect of the consumption of coal in the two cases cannot be ascertained, unless you separate the power which is devoted to heating the air in the shaft, and the mechanical force of the jet. If the consumption of coal in a steam-engine boiler was as complete as it was in the furnace, you may assume that the mechanical power of the jet would be ultra the ventilating heat in the shaft; but then we know as a fact (and those experiments, and the result I have given of several collieries prove it), that you do not get the same result out of coal applied to a boiler, as you do from a furnace. If so, then, the increased power of jet does not compensate for the loss, and you produce a greater result with the furnace alone, than you do with the boiler fires and jet.

3586. Mr. *Stephenson.*] By adding the coal consumed under the boiler to the coal consumed under the other, the one being better than the other, does it make the jet really almost useless?—It does; and any person who has seen a good furnace burning, compared with that of the boiler, will at once be able to judge of it without experiment. It can easily be seen whether the up-cast shaft is ventilated by a boiler or by a furnace. The volume of smoke which comes up the shaft from a boiler fire, as it comes up the chimneys of engines in towns, adds to the weight of the column. In a well-ventilated furnace you see no smoke at all; and there it is that the superiority of the furnace, in the consumption of coal over boiler fires, becomes apparent.

3587. You have alluded to the comparative effect which is produced by the steam jet in the locomotive engine and that which is produced at the bottom of an up-cast shaft in a column; are not the circumstances widely different?—Certainly; they are different in this respect, that the one is probably at the bottom of a 1,200-feet tube and the other of a six-feet tube; but the mechanical action of the steam jet is the same in both cases.

3588. Supposing that the locomotive engine chimney were increased to 600 feet in height, would the steam jet then operate as efficiently as it does now in a very short chimney?—Certainly not; because you have the effect of the jet acting upon a confined elastic body; and, as I explained before, and which is shown in the diagrams (Plates X. and XI.), its action upon the elastic body is to push it up so far; the effect diminishing as the length of column is increased.

Vide Experiments, Appendix.

3589. Is it within your knowledge, that recently the effect of the steam jet upon a locomotive engine, even in the short chimneys which originally were used, has been very much improved by diminishing the length of the chimneys?—I believe it is. I believe that the greatest effective power of the jet is immediately after the steam has expanded, so as to fill the entire chimney. Any increase of length of chimney after that becomes an increase to the friction, and therefore is injurious.

3590. *Chairman.*] Have you anything else to state on this part of the subject?—I think not.

3591. You view collieries in a good many districts?—I do.

3592. You have stated, that in some districts the mode of carrying the air through the workings to the up-cast shaft is very ill attended to; will you state in what districts it is not well attended to?—I believe that up to a very recent period, and even at this moment, it is the opinion in some districts that the splitting

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splitting of air is a very bad thing, and is not consistent with the true principles of ventilation. That is extremely erroneous, as may be seen by examining the synopsis of the Hetton ventilation. That ventilation, as I have before stated, extends over a run of 97 miles, divided into above 30 splits; if that principle had been applied to that ventilation, it would have been correspondingly diminished; and instead of getting 210,000 cubic feet per minute, we should have had much under 20,000 cubic feet per minute. I think that the greatest modern improvement in conducting the air around the workings is in the splitting of it judiciously. No doubt the correct principles of ventilation require to be known before this can be practised; I have myself gone into several pits where the splitting of the air has been very clumsily done, principally by doors instead of regulators. In a properly ventilated pit it is not necessary, if you have 20 splits of air, to have 20 doors. That is done now without any doors at all, doors being extremely objectionable on account of being neglected; it is now done by regulators.

Vide Experiments, Appendix.

3593. What is a regulator?—If you look at figure 12, plate II., you will find a representation of a pit of moderate ventilation; you will find that there are five divisions in that diagram. Taking No. II., you will see that the distance which the air has to travel from the down-cast A. to the up-cast B., is only 6,400 feet; whereas, in No. 1, it travels 19,470 feet. The whole of the air would of course take the shorter distance; and if it was not prevented, no air would go into No. 1. That is done by placing at A. an obstruction, which is called a regulator, to prevent the air from going round No. II., and to interpose as great a resistance to the air in passing round the 6,400 feet as there is in passing round the 19,470 feet. It is the same in the other cases. This is extremely important in conducting the air round the workings of a mine; because, in all the shorter runs, you are obliged to throw as artificially as great a resistance on those short runs as there is on the long runs; and hence it is extremely injurious to have one long run of air in a pit; they should be divided as equally as possible.

3594. Mr. *Locke.*] Do you employ the regulator for the purpose of making the resistance equal in all the various lengths?—You do. Instead of allowing the air to pass through a six-feet square passage, you block that up and make the air pass through probably a two-feet square orifice.

3595. Then, in point of fact, it is an opening commensurate with the distance and the quantity of air you want?—It is so closing the passage as to increase the friction in passing through the regulator, and to throw on No. II. the same resistance in travelling 6,400 feet as if it travelled 19,470 feet. There are five divisions in that pit; when you come to ascertain the resistance of the aggregate air-courses in that pit, each of them must be assumed to have a resistance equal to 19,400 feet. If the 19,400 feet could be reduced to 9,400 feet, then you would have only half the resistance of the air in that pit.

3596. Then do you simply make a stopping at the point A, and make the door or opening smaller than the ordinary air-ways in that particular district?—The regulator is generally placed where there is no passage through, so that it may not be disturbed.

3597. Mr. *H. A. Bruce.*] There is nothing to overlook?—No; and therefore the whole of such a pit as that could be ventilated without a single door, except the two between the up-cast and the down-cast. So that no dependence is to be placed upon the opening and shutting doors; that is now the principle adopted of splitting the air.

3598. Mr. *Locke.*] Then, in point of fact, the regulator is nothing more or less, than an opening to regulate the quantity of air passing through?—Exactly; the resistance of air being in the proportion of the square of the velocity; the smaller the aperture it is made to pass through, the greater is the resistance put on it.

3599. Mr. *H. A. Bruce.*] Would not one advantage of that be freedom from accidents in case of an explosion?—The regulators are less liable to be blown out than doors.

3600. Mr. *Locke.*] Is it thick stopping, or a mere door?—It is generally a thick stopping with a hole through it.

3601. What width of stopping?—It varies very much. In some cases, it is a stopping four or five feet in width, and an opening made on the top of it. It is very desirable that those regulators should be so made, that in case of an explosion

explosion they will not be disturbed; and then, so far as that goes, the air would resume its original state.

3602. So that if the stopping was a thick one, and even the door-way admitting the passage of air were blown out and destroyed by an explosion, still the general principle would remain, the stopping itself being left there?—Exactly.

3603. And, upon the whole, only slightly altered by the explosion?—Just so; the object being so to arrange the air-courses, as that the distribution of the air shall not depend on doors.

3604. *Chairman.*] Having two doors so closely placed between the up-cast and the down-cast shafts, if an explosion were to take place, would there not be a very great liability of those doors being blown away?—You must have a passage between the down-cast and the up-cast; and there is no way of obtaining that passage, except by the use of doors. If you narrow the risk to the compass of two doors, you may by falling doors, in case those are blown out, or by other means, contrive that the opening shall shut of itself, in case of an explosion.

3605. Supposing those two doors were blown out, would not the ventilation around the pit cease, inasmuch as the air would merely go down the down-cast shaft and up the up-cast shaft?—Yes.

3606. You say, that modes can be suggested of having a sort of trap-door which, if the ordinary door were blown away, would fall down and keep the ventilation in a perfect state?—Yes. Mr. Buddle had a form of swing door, which he explained in his evidence before the Committee of 1835, supported by a prop; and in case of that prop being thrown out, then the door swung down and so restored the ventilation.

3607. Mr. *H. A. Bruce.*] A sort of portcullis?—Yes.

3608. Mr. *Locke.*] In point of fact, might it not be made to work in any way?—Yes, several modes might be suggested

3609. Mr. *Stephenson.*] It is hung on a hinge?—Yes.

3610. *Chairman.*] Is that system now used extensively in the north of England?—The system of distributing the air, by means of regulators instead of doors, is now used.

3611. Where the doors are placed between the two furnaces, are the trap doors of which you have spoken, also placed there generally?—No; they are not. Those doors being close to the down-cast, in case of an explosion, they are easily accessible; and it may be that the pit B, instead of being placed immediately opposite the down-cast, may be at the extremity of the workings; and in that case there will be no door at all.

3612. Supposing the pits are placed in the position you have described in figure 12 of plate II., do you think that it is not necessary, at all times, to have the trap doors to which you have alluded, because you have been understood to state, that the down-cast pit should be easily accessible; and might not an explosion occur of so great a magnitude that the machinery would be blown up the pit, and there would be no means of letting the men down?—It would be very desirable to adopt some door which would close the aperture, in case of an explosion; but it must be a very heavy explosion indeed to blow away the doors near the shaft.

3613. Provided those doors were blown away and the machinery of the pit injured by an explosion, there being no trap doors, your mode of ventilation would be of no service, inasmuch as the air would not travel round, but would get directly from the down-cast to the up-cast pit?—It would be entirely destroyed.

3614. Therefore, in order to complete the ventilation, and make it perfectly safe, with the regulators of which you have spoken, would it not be necessary to adopt some system at these two doors by which, in case of an explosion, the air should be shut off, so that it must travel all round the workings?—It would be desirable to do so.

3615. Do not you think that is necessary in order to complete your system?—I think so.

3616. Mr. *Stephenson.*] Would it not be feasible to have such a door as has just been described as a sort of portcullis, with which a communication might be made to the surface?—There are various modes in which it might be done.

3617. *Chairman.*] You have no doubt, in point of fact, in your own mind, that

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that something might be suggested which would take the place of these doors, in case they were blown away, so as to render the ventilation safe?—I think so.

3618. Mr. *H. A. Bruce.*] That danger being guarded against, would there be considerable security in this system as compared with the usual system of ventilation?—Yes; so far as the doors are concerned. What we have to contend with, in case of an explosion, is the explosion blowing out the stoppings.

3619. Are they much less likely to be removed than ordinary doors?—Yes.

3620. *Chairman.*] Do you think there would be any difficulty in making those stoppings or regulators sufficiently strong, that no explosion you have ever known to take place would blow them out?—The regulators could be made sufficiently strong that they would not be blown out in case of accident, but it is more difficult with the stoppings.

3621. What are those stoppings?—Those are the stoppings in the passages which have been made in working the colliery.

3622. Are those the stoppings through which the men and the tram carriages have to travel?—In some cases they are; but the roads are now so disposed, and the air is conducted in such a way, that there is in large pits very few doors indeed. I think that in Hetton Colliery there are not three doors in each pit throughout the whole of the workings, unless it is where the bords are necessary to be ventilated by brattices, and doors are required at the end of the brattices; and, in that case, those doors are made swing doors.

3623. Are those doors in such a position, that if an explosion were to take place, and they were blown down or carried away, it would injure the whole of the ventilation, and a great many men be killed by the after-damp?—No; they would not disturb the general ventilation of the colliery, but only the particular part in which the explosion occurred.

3624. Therefore, supposing an explosion were to take place in one particular point of a colliery, would the men have any difficulty in getting into a place where they would get fresh air, and be removed from the effect of the after-damp?—If the general currents of the pit could be so arranged as to be undisturbed in case of an explosion, then the destruction of the swing-doors in the different districts would be less disastrous.

3625. Could such an arrangement be made without any great difficulty?—I think so, without any increase of cost, by a proper arrangement and distribution of the air through the workings.

3626. Are such arrangements made in the best ventilated pits in the north of England?—They are, generally: the main currents of the air are now carried round the pits, without the use of doors at all.

3627. Therefore, if an explosion were to take place in some of the most fiery mines in the North of England, the probability is, that there would not be such an enormous sacrifice of human life as occurred some years ago in the Wallsend and other pits?—I cannot say that accidents would be done away with, but they would be rendered less disastrous by such a mode.

3628. Will you explain to the Committee the formula to which you allude at page 35 of your pamphlet?—It is Mr. Hawksley's formula, founded on the resistance of air in the gaspipes. Mr. Greenwell, at my suggestion, made an experiment on the resistance of air in Crookbank Colliery, which is corroborative of the formula of Mr. Hawksley. The particulars of that experiment I deliver in. (*The Witness delivered in the same.*)

Vide Appendix.

3629. Is the mode of splitting the air very much neglected in some of the districts which you have visited?—I have found it neglected.

3630. In the district of South Wales is it attended to?—Partly, but not sufficiently.

3631. Do you think that at Hetton, or any other large colliery, any amount of air would be sufficient, if you did not pay proper attention to splitting the air, and carrying it to every part of the workings?—I think, generally, that the safety of the mine depends more perhaps on the proper distribution of the air, than on the quantity which is got into it.

3632. Do you think that it is necessary that each workman should have, as far as possible, a proper proportion of fresh air unimpregnated with gaseous matter?—I think that in all well ventilated collieries, there is always a superabundance of air for the workmen. The mine itself, to be properly ventilated, requires more air than is necessary for the workmen.

3633. Is it your opinion, that in every district there are collieries which are very

very ill ventilated, and into which sufficient air is not brought, either for keeping the colliery in a safe state, or if there should be explosive gas, for keeping it in such a state as not to be injurious to the health of the workmen?—I think there are a vast number of collieries in the country where the ventilation is such, that there is not sufficient air to carry on a proper ventilation, or sufficient for the health of the workmen.

3634. Do not you think that one of the chief duties of the Government inspectors should be, to see that sufficient air was brought into a colliery, not only to render it safe, but also that the workmen might breathe a sufficient quantity of fresh air to keep them in a healthy state?—I think it should be the duty of the inspectors to see that there was a proper quantity of air, and also that it was properly distributed. I think, in addition, there should be some means either of inducing or compelling the owners to adopt those measures.

3635. Do you think that any colliery ought to be carried on with what is called natural ventilation?—Certainly not.

3636. Do you think it would be wise in the Legislature to make it imperative by law, that every colliery owner should use some system of ventilation, to increase the ventilation in the colliery?—I think there should be some legal measure which would compel mines to be properly ventilated.

3637. You think that cannot be done by what is called natural ventilation; that is, the difference between the temperature of the up-cast and the down-cast shaft?—I think not, because the temperature of the return air from the workings, is as nearly as possible the same throughout all periods of the year; and the temperature of the down-cast shaft is varying almost daily, so that at one period of the year, the temperature of the air going down the shaft, is almost equal to the temperature of the air going round the workings.

3638. In that case, would the ventilation almost cease?—Yes; or become so weak as to be useless.

3639. Have you ever had an instance of its entirely ceasing?—I have known instances where you could not tell which was the up-cast and which was the down-cast.

3640. Do you think it is practicable to clear the goaves of foul air?—I think it is not practicable to act on the principle of clearing the goaves of foul air. I have some doubt whether that is the principle which ought to be acted on; some goaves being safer filled with inflammable air, than they would be under circumstances of a partial ventilation. I think the partial ventilation of a goaf is extremely dangerous, and that unless you can completely ventilate it, it is better that it should not be ventilated at all.

3641. Unless the goaf could be effectually ventilated, so that the whole of the inflammable air could be got out, you think it would be more dangerous to allow the atmospheric air to go into the goaf at all than to keep it tightly stopped, so that no atmospheric air could enter it at all?—Yes.

3642. Your reason for that is, because the atmospheric air entering and combining with the inflammable air, would render it explosive; whereas, if no atmospheric air entered, it would be in an inexplosive state?—Yes. If the goaf is kept filled with pure inflammable air, and the pressure of that air always outward from the goaf into the air passages, so that if there is any air coming out of the goaf, it is carried away. The air should be so regulated around the goaf as that there should be no pressure of air into the goaf. If you have the tendency of the air to press outwards from the goaf, although it is filled with inflammable air, it is perfectly safe; but it depends upon the arrangement of the air currents being such that the pressure is always outward into the air currents, and not out of the air currents into the goaf. You cannot insulate a goaf to render it safe, unless you bring about those circumstances.

3643. Do you think it is not possible to stop up the goaf so tightly that no atmospheric air can enter it, or no foul air come out of it?—I think it would be unsafe, unless you could so arrange the air-courses as that the pressure of the goaf air was out of, and not from the air-courses into, the goaf. No plastering up of the goaf, in my opinion, would be safe unless you had the air-courses so arranged.

3644. Is it necessary that a good current of air should play round the goaf at all times?—I think it is necessary that a good current of air should be taken around the goaf at all times; but if a goaf is to be insulated, that current should not go round the goaf. If you take a current of air round a goaf, there is a ten-

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dency in the up-going current to go into the goaf towards the down-going current; and in that case, you cannot insulate the goaf properly.

3645. Supposing the goaf is square, what would be the safe way of carrying the air round the goaf?—It should go up the two sides, and along the face, and not go up one side and down the other, the general principle in the insulation of goaves being, that any particle of air coming out of it travels the shortest distance to the up-cast shaft.

3646. Mr. *Stephenson.*] Suppose the goaf to be in the form of a foolscap sheet of paper, and the air entering the goaf at the lower angle, and being driven away from the upper angle, the distance which the air will have to traverse along two sides would be precisely the same as the distance which the air would have to travel along the other two sides?—Yes.

3647. Therefore, there will always be, as it were, a partial vacuum in the air-course?—Yes; a tendency of any air exuding from the goaf to go away from the goaf into the air-courses, and not to press from the air-courses into the goaf.

3648. If you attempted to circulate the same current of air round the whole circumference of the goaf, would the tendency be for the air to pass in on one side, and to run across into the opposite side?—Yes; because it will always follow the shorter course. The tendency of the air would be to go into the goaf, and cross the goaf to get to the other side of it. Under such circumstances, the insulation of the goaf would not be safe, although you plastered it, because plastering would be liable to crack, the air would get into the goaf; it would be partially ventilated, and it would be explosive; whereas, if the tendency of the air is outward, then no atmospheric air would get into the goaf; and if the goaf were filled with pure firedamp, it would be safe.

3649. *Chairman.*] Ventilated in the way you have described it is possible to ventilate, would a goaf of any extent be quite safe?—I think so; and I doubt the attempt to make goaves safe by ventilation. I think the difficulties of doing so are so great, that it is more safe to act on the principle of insulating them, and of carrying the air-courses around the goaf, as to carry off any exudation of fire-damp from the sides of the goaves, than to act on the principle of ventilating them.

3650. What is your opinion of the Report of the Committee of 1852, as to putting bore-holes down on the goaves?—I think it would be perfectly inoperative. I think that the effect of bore-holes on the goaves would be probably to send air down into the goaves, and certainly not to take air out of them.

3651. Mr. *Stephenson.*] And most likely water?—Most likely water.

3652. *Chairman.*] As a practical man, do you think that such a system could be carried out; or that if it could be carried out, it would have any beneficial result?—I think it would be quite ridiculous to attempt it; and I think, if it were carried out, it would be perfectly useless.

3653. Mr. *Stephenson.*] If it were a down-cast, bringing fresh air into the goaf, would it not be the very thing which you do not wish to have done?—Yes; if you put a bore-hole, the possibility, in fact, the almost certainty is, that the air would go down through that bore-hole into the goaf; and if o, it would be a partial ventilation of that goaf.

3654. *Chairman.*] The Report of the Committee of 1852, is also, that the steam jet should be put on the top, so that the bore-hole should, under all circumstances, by the steam jet, be made the up-cast; what is your opinion of that?—My experience leads me to the conclusion, that no steam jet placed on the top of the bore-hole would make it an up-cast.

3655. In your opinion, should naked lights at any time be carried round the goaves, or in the vicinity of the goaves?—I think that, as a general rule, if goaves are liable to be filled with inflammable air, it is not safe to carry naked lights round them, or to allow the use of naked lights round the edges of the goaves. If the goaves are filled with carbonic acid gas, then I do not see any objection to it.

3656. In your evidence in 1852, you stated that you did not believe in the natural brattice. Have you modified your opinion in any way in that respect?—Not the least; I have never been able to see an instance of natural brattice in my experience in a shaft. Certainly, so far as regards ventilation, it is perfectly absurd, because no state of ventilation, which can be called ventilation, will admit of a natural brattice.

3657. If

3657. If the air-ways are sufficiently large to fill up the up-cast shaft with air, is it possible that such a thing can exist as a natural brattice?—Certainly not; and that is still further shown to be inconsistent with practice, inasmuch as, in sinking a shaft, you are obliged to carry a real brattice down the shaft, for the purpose of inducing the air to go down. In sinking a pit, you can only go a certain distance below that brattice, otherwise the air is stagnant, although in that case the effect of the brattice is, to throw the air down the shaft.

3658. May not the steam jet, or any other system of ventilation, make a sort of a vacuum below, which may induce the air to go down, if the airways are not sufficiently large; and in that case may you possibly have a natural brattice, but under no other circumstances?—I cannot very well conceive the case of air going down one part of a shaft, and coming up the other to any extent; I do not say that it would not to some extent do so. In the Monkwearmouth Colliery, which is a very deep one, we have the fact of fresh air going in along the bottom of the seam, and the heated air returning along the top; and that acts to such an extent as even to carry air into the face of the workings to a certain extent, but that acts horizontally, or nearly so.

3659. It was recommended in the evidence given before the Committee of 1852, that in cases of violent explosions there should be large openings called "Refuge Stalls" left, with a sort of valve propped open, which prop would be blown out, and that into the refuge stalls the men might go, and retain life for a certain time, and escape the effects of the after-damp, until fresh air could be got to them; is it your opinion that refuge stalls are practicable?—I think they are impracticable; I have considered that matter very carefully since that Report was made. I have had occasion to attend to a great number of explosions, and I have been myself the subject of explosions, and I cannot see that in any one of those cases such a thing could have been useful or practicable. If there is any respirable air left in the pit after an explosion, it is generally in the face of the workings; and if there is any place of refuge by which life may be prolonged, it would be by the man remaining in the face of his bord, rather than going into the after-damp to get to a refuge stall.

3660. Do you think that the men in their fright, forcing their way to the mouth of the pit, generally rush into danger rather than avoid it?—In the case of an explosion men are very much confused; but I do not see the possibility of keeping a refuge stall filled with respirable air, unless it is hermetically sealed; and a man going into it (that is supposing he could get into it at all), would take the vitiated air with him.

3661. But he would only take as much air as would go in while he was entering, and the door would be dropped behind him?—In an explosion the pressure of air is enormous. I was myself in a pit when it exploded; I was anxious to throw myself down on the floor of the mine, and I could not do it; the air was so dense, that I floated on the top of the air next the roof, the density being greater than water; and if you conceive any opening into a refuge stall, the pressure of air into that stall would be so great, as to compress the air and drive it out; unless, therefore, it was perfectly air-tight, I do not see how the respirable air could be kept in; and then supposing the explosion over so as to allow the men to travel to it, still in that case you have the bad air surrounding the place.

3662. Supposing that the refuge stall could be made perfectly air-tight, do you think it could be made to hold 30 or 40 men, and enable them to retain life for any time?—Certainly not. How were the 30 or 40 men to get to it?

3663. Mr. *H. A. Bruce.*] Is it not after the explosion that the air is dangerous?—Immediately after the explosion you cannot breathe it.

3664. If the explosion is the signal of danger, would you not have to traverse the exploded air in its most dangerous state, in order to get to the refuge stalls?—Yes. The only safe place in a pit, in an explosion, is in the face of the bords where the air is pent up to a certain extent. The danger would be in travelling to the place of refuge.

3665. *Chairman.*] You think that the face of the pit is the best refuge-stall that can be made?—Until the explosion has passed, and as much atmospheric air is mixed with the vitiated air as will enable a person to turn out. Applying it to cases of explosion which I have studied, I could not see in what part of a pit such refuge stalls could be placed, to be useful in an explosion.

3666. It was a recommendation in the Report of the Committee of 1852, that an

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anemometer placed in a pit should be a self-registering anemometer; and that, with reference to the periodical visits of the inspector, it should be so placed that he would know at each visit the rate at which the current of air had been passing through the mine in his absence; in your opinion would such a self-registering anemometer be a safe guide, under any circumstances?—I think that, applied in the way the Committee recommended, it would not be a guide on which confidence could be placed. It is possible to have a self-registering anemometer, which would register the rate at which the air travelled for a certain period; but I think not for so long a period as the interval between the visits of an inspector.

3667. Supposing the visits of the inspector were weekly or monthly, do you think that the anemometer could be so constructed that it could not be tampered with by an overman, who had a wish to make the air appear to have been going faster through the pit than it actually had gone?—I think the object might be defeated, by removing the anemometer, and placing it in another place; or by so contracting the air as to make it run round very rapidly.

3668. By contracting the space where the anemometer is placed?—Yes; and I think that is a difficult and erroneous principle of relying on the prevention of accidents, or for ascertaining the velocity of the current. The best detector is an anemometer placed near the furnace of the pit; and that the record of that anemometer should be reported to the manager of the mine, from time to time, and examined by the overlookers at uncertain periods. At most of our furnaces we now have an anemometer of that kind, by which the overman, or the viewer, or any one who goes there unexpectedly, can ascertain the rate at which it has been moving.

3669. Still you, as the head viewer, as well as the inspector, would always be dependent upon the honesty of your under-viewer, who is constantly in the pit?—Certainly. But more than one person having the surveillance of a registry of that kind, there must be a combination in cheating before any tricks can take place; and then I do not see the object of such trickery.

3670. Would you consider your pit safe if you were to place your whole dependence on a self-registering anemometer, provided you did not think the overman was an honest man, and a man who would not, under any circumstances, tamper with the anemometer?—I should not consider it safe to rely upon an anemometer to be watched by the inspector. The correct principle of safety is to have honest and efficient managers.

3671. Or by yourself?—Or by myself; I think the mine should be inspected from time to time by competent and honest overlookers.

3672. And therefore it would be infinitely better to have honest people in a mine, than to depend upon any scientific instrument?—Certainly; it is the only safe mode of conducting a mine.

3673. At the same time, you do not mean to undervalue the use of the anemometer?—Not the least; on the contrary, we have used the anemometer for years, and I have always stated in my evidence on these occasions, that I thought an anemometer placed near the furnace was the best mode of testing the quantity of air going into the pit, and better than the water-gauge.

3674. Mr. *Ingham.*] If the anemometer were fairly dealt with, would it give the inspector the amount of the ventilation in his absence?—At the particular point at which the anemometer was placed; but that would be no indication of the air going round all the workings. For instance, looking at the diagram (Fig. 12, Plate II.), supposing I set those shaft doors open, the anemometer, being placed near the furnace, would go at a tremendous rate, and not a particle of air would be going round the pit.

3675. Supposing the place was originally chosen with the knowledge of the inspector, so as to place the anemometer where it would give a good record of the ventilation in the pit, if that were fairly dealt with during his absence, would it not denote the amount of ventilation during his absence, supposing he came back within a month?—Yes, if it recorded it so long.

3676. Then is it not an act which would be obnoxious to the workmen to tamper with the anemometer, because they would know it would put the ventilation in jeopardy on which their safety depended; and do not you think that information would be given to the inspector, if, during his absence, the anemometer had been removed, or the process had been fraudulently interfered with?—I do not think there would be any objection, on the part of the coal-owners, to such

such an anemometer being placed in the pit; but I think that it would be a false security to rely on one anemometer for any degree of safety. If, as at Hetton, you have 33 splits of air, you must have an anemometer in each split; and then you must have them in many other places, because those splits are again split into other portions, and at those extremities where the greatest danger exists.

3677. *Chairman.*] You might have an anemometer in every current at the same time, and the workmen might inform if an overman tampered with the anemometer; but at night the workmen are not in the mine?—No.

3678. Therefore at night, if a man were inclined to tamper with any one of the anemometers (and the more anemometers there were, the more readily he could tamper with them), it would be necessary to have a man every night, and all night, to watch each particular anemometer, and guard against the anemometer being tampered with?—Yes; the more you increase the number of anemometers, the greater is the difficulty of inspecting them. I do not mean to say that the coal-owner would object to anemometers being placed in any part of the pit; because the coal-owner, being of course responsible for the safety of the mine, would be as much interested as the inspector, in seeing that they were right; but I mean to say that it would be a very troublesome and difficult mode, and not an efficacious mode, of testing the safety of a pit. I think it must be done by other modes to be effective or of any utility.

3679. In a serious case of explosion, is the proprietor of the pit put to considerable expense?—To very great expense generally.

3680. In any pit of which you have had the management, where a very large explosion has taken place, to what expense was the proprietor put?—It depends very much on the circumstances. I have known an explosion cost a coal-owner many hundred pounds; and in some cases the pits have been shut up. In two or three cases within my experience the pits had to be shut up two or three months.

3681. Mr. *Stephenson.*] So that it is not merely having to repair the damage, but it is the loss of business during that time?—It is the loss of trade during the interval.

3682. *Chairman.*] It appears by returns that nearly one-fourth of the accidents in England have happened from falls of the roof and sides on the heads of the men; can you suggest any plan by which those accidents could be prevented?—I do not think I can suggest any other plan than care and attention; and the plan which is at present pursued, of propping the roof and sides. The process is very simple, by either props, or blocks of wood placed transversely, which we call "chocks." Recently the use of square pieces of wood or chocks has been very much extended in the north of England, and I think they are safer than the ordinary props; they cover a space of something like four square feet, and they are consequently a better support to the roof than a single prop. Single props, however numerous, are liable to be broken down, and falls of stone take place. In all those cases care and attention are the only precautions that can be adopted.

3683. It has been stated, that in the Northumberland and Durham districts, there are men who are called "deputies," who stand the props; and that in the districts of Lancashire and Yorkshire, the working men are generally in the habit of standing the props themselves: in your opinion, which is the best system?—I think that the system of employing men exclusively for that purpose is better than employing workmen generally. I am well aware that, in the Midland counties, a contrary opinion is prevalent; but I still think on principle that the deputies, being men of a superior class to the general class of workmen, and being constantly employed in that duty, and of course having great experience in it, are a class of men more safe to be employed than the ordinary workmen.

3684. Do you think their superior ability, and superior practical knowledge of the state of a roof, would more than counterbalance the care which the working men may be supposed to take, to insure the safety of their own lives?—I think that a great many of those accidents occur from the carelessness or inadvertence of the workmen, and I think that the deputies would take more care of the workmen than the workmen could take of themselves. The workmen are generally absorbed in their work, and consequently unable to see the danger.

3685. In your experience have you generally found that sufficient supports are always furnished to the deputies or to the workmen?—Yes, and for this very obvious reason, that a fall of stone is a great expense to the coal-owner in clearing

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it away; and that, even in a mercenary point of view, the coal-owner is interested in having as few falls as possible.

3686. At the same time, is it not the fact, that the coal-owner sometimes does not know his own interest; for you will probably think that coal could be worked cheaper with sufficient ventilation than with a system of natural ventilation, and that the coal-owner, in many cases, will not lay out his capital to work his coal properly, and is therefore working at a more expensive rate?—I think that a well ventilated colliery may be worked cheaper than a colliery which is not well ventilated; but I doubt very much whether the coal-owner in a district where a colliery is badly ventilated, thinks so. I apprehend it is because he thinks he may save something by the want of ventilation, that he keeps his pits in that state.

3687. On the same principle, may not the coal-owner think he will save something by not providing a sufficiency of props?—Probably he may; but in that case I am sure that the saving in the want of props would be less than the expense of removing the falls when the falls take place.

3688. In both cases your opinion is, that if the coal-owners think so, they take a very improper view?—Yes; and I think they take a very erroneous view.

3689. With regard to the method of winding men up and down the shafts, it appears, on looking over the returns, that more than 200 men lose their lives annually from accidents in and about shafts. In the district with which you are more particularly acquainted, after the pits are abandoned, are they generally walled up?—The pits are always secured when they are abandoned. The number of abandoned pits in Northumberland and Durham are very few. I do not know any case in that district in which accidents have happened by men falling down the old pits.

3690. Have you seen pits totally insecure in other districts?—Yes; where the pits are numerous.

3691. In your opinion, should it be enacted by the Legislature that every abandoned pit should be walled round or properly secured, so as to prevent accidents?—I think it would be a very proper measure.

3692. Is it not very possible that the grass might grow over the top of a small pit, so as to render it almost impossible for a man to see that he was walking into a pit, and would fall down it and be killed?—It is so, in many cases that I am acquainted with, in the outlying districts, where the pits are numerous, and of no great depth. I have known accidents happen; and I think it would be a good measure to insist upon their being walled around.

3693. In your opinion, is sufficient care taken to keep the pit or the shaft in a proper state, so that no stone or rock can fall on the heads of the men?—I think, in the Northumberland and Durham districts, that is very particularly attended to. In deep shafts, very great care is taken either to wall them, or to see that the rock which is not walled is sufficiently firm to stand without walling.

3694. Mr. *H. A. Bruce.*] Do accidents happen more frequently during the sinking of a pit than afterwards?—I have not known many accidents happen in sinking. I sunk two shafts 280 fathoms in depth not long ago, and no accident occurred.

3695. *Chairman.*] It has been stated that in some districts the shafts are left in a very unsafe state, and that men constantly lose their lives from stones and other things falling from the shafts. In your opinion, should it be one of the duties of the inspector to see that the shafts were in a proper state, and, if necessary, were walled up, so that nothing of that kind could occur to kill the men?—I think it is peculiarly the province of the inspectors to see that the pits are safely walled off or secured. That is just where, I think, the inspector would be useful.

3696. It has been stated to this Committee by some of the workmen, that a great many accidents occur from too many men being wound up and down the pit at the same time, and also by men being let down the pit when full coals are coming up, and also by the great speed at which the men are wound up the pit; do you think that anything could be done to render these accidents less frequent?—I think that in all well-regulated collieries there is a rule laid down, as to the number of persons who are to ascend or descend the pits, and, of course, the mode in which that is to be done. I find, in my experience, very often that extreme difficulty exists in preventing more men getting on the rope than is laid down by the rule; the rule in every case being, of course, the safe number. The dangers and the accidents almost always arise from more men

getting

getting on the rope than the rule prescribes. I do not think that many accidents happen from the velocity with which the men ascend or descend; because, with a properly constructed apparatus in the shaft, you go as smoothly at 10 miles an hour as at five; and I do not fancy that there is much in the velocity if the shafts are properly arranged.

3697. Do you think that the engineer has the same power over the engine, if it is going at an increased rate of velocity, as he would have if it were going much slower?—In all well-regulated machines there is a bell, which is rung at a particular point of the ascent, and then the engine-man reduces the speed and ultimately stops the engine.

3698. The engine works with a fly-wheel?—Yes.

3699. Is it not more difficult to stop an engine, when it is going very quickly, than when it is going slowly?—No doubt; but the brake gives great power over the rope-wheel of the engine.

3700. Is there not a point of speed beyond which you would not recommend men to be wound up?—Yes.

3701. Can you give the Committee an idea as to the average rate of speed, and as to the rate of speed which you think would be more safe to wind men up and down?—I think, in a pit of about 600 feet, the time of drawing coals is about a minute; and I think, as a general rule, it is laid down, that the men ought not to come up at more than half the rate at which you are drawing coals.

3702. Do you think they could be wound up, with perfect safety, at the rate of 600 feet in two minutes?—Yes.

3703. Mr. *Stephenson.*] What is the comparative safety between 600 feet in two minutes, and 300 feet in two minutes?—The comparative safety is in relation to the velocity.

3704. If an accident took place in the slides, do you think it would be possible for a man to ring the bell in a shaft at slow speed, and to prevent any evil consequences by that arrangement?—I think not. When I spoke of the bell, I did not mean that the men should ring the bell, I meant that there was a bell placed on each engine, and that bell was rung in the machine-house at a certain period of the ascent, and that this gave the man notice to check the velocity, so that when it came to the top it would be at a slow rate.

3705. It has been stated in evidence, that it is possible at a slow speed, when men are being drawn up, to get access to a small auxiliary rope hung down the shaft, by which means they might ring the bell themselves, if anything went wrong. Do you believe, that upon any accident occurring to the slides, the men could take advantage of such a mode of communication with the engine-man at the top of the pit?—Practically, I do not think it would be a safe thing to rely on. The only accidents by velocity, are those where men are taken up over the pulley-wheel. In one of the pits, of which I have the charge, I believe there are only eight feet between the top of the pit and the bottom to play upon, in drawing the coals, and the men cannot see the pit; and yet we have never had an accident happen in that shaft in drawing coals. It proves the facility with which they stop the machine.

3706. *Chairman.*] Have you ever used Fourdrinier's or White and Grant's cages?—I have used Fourdrinier's, and a modification of it.

3707. What is your opinion of it?—Generally, I think they have not been practically useful; they are very liable to get out of order; and I have, in several pits, abandoned the use of them. In some of the pits they are still at work; but generally, I have great doubt whether they are a saving of life. I have known accidents happen in consequence of the use of them; and certainly the liability to get out of order is very objectionable; and the feeling of the trade is, that they are not so efficacious as they were at first thought to be.

3708. At the same time, might not a cover be placed at the top, so that if anything fell out of the pit, or on the top, it would fall on the piece of board, or whatever was above, and the men's lives be saved?—I think that in all cases there ought to be a cover on the cages in which men descend. Fourdrinier's is a mode of stopping the cage in case the rope breaks. There may be too great a tendency to rely on the apparatus, and so allow the rope to wear nearer a breaking condition than previously; therefore, I have great doubt whether they practically operate to prevent accidents.

3709. Is it not quite possible also to have a sort of cover at the top of the pit, which

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which might be lifted up as the bucket came up to the top, and when the bucket went down, that cover be left on the top of the pit, so that both sides of the pit would be safe, and a man could not walk into it?—I do not think that many accidents happen by men walking into a pit.

3710. It might easily be avoided?—I think it would be attended with some inconvenience in practice. If it was a down-cast or an up-cast shaft, it would be an obstruction to the air.

3711. It might be made of iron bars, placed across one another, so that there would be but a slight space through which the air could not travel?—I have heard of no accidents by that mode. I think the expense and inconvenience would be far more than any benefit which could be derived.

3712. You have not seen it done at the Dowlas colliery?—Yes, I have.

3713. Do you think that is a good mode?—I do not think it is necessary.

3714. Do you think that any rate of speed could be enacted by the Legislature; or do you think it should be in the power of the inspectors to see that sufficient care was taken as to the goodness of the rope and the machinery, and also that proper engine-men were employed, so that men's lives might not be in danger?—I do not think the Legislature could lay down any particular rate of speed; because, in my mind, the only danger in the rate of speed is at the top of the pit; and with a very deep pit, you have a longer distance to travel before you come to the top, than in a shallower one. The same rate of speed would not be safe in both cases. I think it should be left to the inspectors and the coal-owners. I think that certain rules should be laid down upon which the inspectors should act.

3715. Are there any particular rules laid down in your collieries?—Yes, in all the collieries.

3716. Have you any particular rules connected with any collieries over which you have the charge?—Yes.

3717. Have you any objection to put in a copy of those rules?—I will go into that question when I speak of the inspection, as I purpose saying something about such rules; and probably that will be the best time to do it.

Jovis, 14° *die Julii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Ingram.
Mr. Child.	Mr. Henry Austin Bruce.
Mr. Mostyn.	Mr. Cayley.
Mr. Baird.	Mr. Cobbett.
Mr. Locke.	

EDWARD JOHN HUTCHINS, Esq., IN THE CHAIR.

Nicholas Wood, Esq., called in; and further Examined.

N. Wood, Esq.

14 July 1853.

3718. *Chairman.*] DO you agree with the Report of the Committee of 1852, as to there being what they call the "furnace limit"?—The limit of the furnace is the same limit which there is to all mechanical power; there is a limit to every thing. But the power of the furnace is sufficient, I think, in every case of mine ventilation, and I have not yet seen any other mechanical power superior to the furnace in power for that purpose; there is just the same limit to any engine, any machinery, either in the shape of a fan, or a pumping-machine, or steam-engine; there is the same limit to any of those powers as there is to the furnace.

3719. Do you not allude to the furnace as a mechanical power?—Yes; the heat acting upon the air in the shaft is a mechanical power, in the same way as Mr. Ericsson is now endeavouring to get by means of heated air a greater and more economical power than steam in steam boats. It is exactly the same principle whh the furnace acts in the application of the heated air in a shaft.

3720. Have

3720. Have you ever practically experienced what is called the furnace limit, so that the increased heat would create no greater effect in ventilation?—At the Hetton Colliery we have one furnace, and we get a certain amount of mechanical power by that one furnace. When we add two more furnaces we get about double the power by the additional furnaces which we have in the single one. If we were to add more furnaces and increase the area, or deepen the shaft, we would increase the power.

3721. Mr. *Child.*] In what proportion do you get additional ventilation by additional heat?—A reference to the table of my experiments shows the increase of power in a column of air between 120 feet and 1,200 feet. That is the increase of power by the increase of depth. The table also shows the increase of power by the increase of temperature.

3722. You mentioned that you got double the ventilation by increasing the furnaces; did you increase those furnaces double, or less than double?—With a nine-feet furnace we got down 164,000 feet of air, and with two eight-feet furnaces, in addition to the nine-feet, we got 234,000.

3723. Mr. *H. A. Bruce.*] Where were those other furnaces applied?—They were applied to the other side of the pit.

3724. In the other shaft?—No; in the same shaft. The application is shown in Plate I.

Vide Experiments, Appendix.

3725. *Chairman.*] The Committee understand you to say that whatever limit there may be to furnace ventilation, the same resistance that would cause that limit would equally apply to any mechanical power, or to the steam jet?—The furnace, the steam jet, and Stuve's machine, are all mechanical powers, and there is no limit that has been attempted to be applied to the furnace, which does not equally apply to the whole of those powers. If you have one boiler it will produce a certain amount of steam, whether that steam is made to apply to ventilation by a jet, or by pumping; that is the limit with one boiler. Then you add another boiler, and then you get a similar limit. Then you may go on adding another boiler and another boiler, but there is a limit with each boiler, and so it is with the furnace. You may apply one furnace, and you may fire that furnace at different rates of intensity, and then firing it with the maximum intensity there is a limit to that furnace. Then you add another furnace, and another, and so on, and there is a limit to each furnace; so there is a limit to the boiler power, or any other mechanical force employed.

3726. Mr. *Cayley.*] Is it not true that the pull which you get from the furnace increases in an arithmetical ration, whilst the drag increases in a geometrical ratio?—It is so; the mechanical effect produced by the furnace, or by any machine, is exactly the same; all those are in arithmetical proportion to the power employed; the drag of the air is in the geometrical ratio of the velocity of the air.

3727. Using all the power you have from the furnace, and the drag increases in that additional proportion, is it not the fact that you soon come to what is called the furnace limit, by that means?—No doubt; just in the same way as you come to the limit of any other mechanical power.

3728. Supposing the case of the power of the jets being greater than in your experiments, although the drag may increase in that ratio, still may not there be in the jet a power in reserve which would still go on multiplying the power of ventilation, in spite of that tendency?—The jet acts precisely the same as the furnace: if you have a steam-jet of a certain quantity of steam per minute at 20 lbs. per square inch, which produces a certain effect; and you have another steam-jet of 40 lbs. to an inch, that produces a certain greater effect, but each of them has a limit; they can only produce a certain amount of drag in the pit, the same as the furnace.

3729. Then the result will depend upon whether there is more or less power in reserve in the case of a furnace, or in the case of a jet?—It would, abstractedly speaking, whether there is more power in the jet to spare than there is in the furnace.

3730. The mode in which the furnace limit would be indicated would be by the tendency of the column of air to descend from the top when the furnace limit had arrived?—By a uniform velocity in the current.

3731. That would tend to obstruct the ventilation?—If the air did descend it would obstruct the ventilation.

3732. Down the up-cast?—The tendency to descend the up-cast.

3733. When the drag and the pull meet at a certain point, as the furnace limit,

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the tendency would be, would it not, for nature to vindicate herself; the tendency of the air which would not come through the galleries of the pit would be to descend down the up-cast?—Certainly not, if there is any velocity, I should almost say perceptible velocity of air, in the shaft. The up-cast shaft you may suppose to be a portion of the rope, which, if continued, would constitute the drag of the air; and the upper portion being that part which is pulling; so long as there is any motion, every particle of the air of that shaft will pull; and there is no tendency of the air to descend, because it is inconsistent with the principles of elastic fluids when heated.

3734. The question assumes that the furnace limit has been reached, and that the current was not very perceptible, if at all; would there not be a tendency for the furnace to be fed by air from some source, and if it failed to be fed from below, would not the air have a tendency to rush down the up-cast to feed the furnace, and so obstruct the ventilation of the mine?—Speaking as a matter of fact, I have seen hundreds of furnace shafts, and I never saw any furnace where there was a perceptible current in the air going down a shaft. I believe the fact to be, that every particle of air in the shaft is heated above the temperature of the down-cast shaft by the operation of the furnace, and that must be the case when there is even a very moderate quantity of air passing over the furnace; then, if you admit that every particle in the shaft is heated, all the particles must ascend, and none will descend.

3735. Under the circumstances of the shaft, you do not believe in the possible formation of what is called the natural brattice?—The strongest case of a natural brattice would be in sinking a pit, where there is no drag of the air at all. In sinking a pit, we find that we require a real brattice to be placed in that pit, so that the air should go down one side, and come up the other. If there was any natural brattice, (which is more imaginary than real), it would be in a still shaft where gunpowder is used, and the heat of the men in the shaft has a tendency to heat the air at the bottom of the shaft; this heated air would have a tendency to ascend, and it would of course cause some air to descend; and I do not mean to say that it does not; I believe it does in fact. But then the quantity that descends is so trifling, that in sinking a pit you are obliged to have a brattice within something like 10 or 12 feet of the bottom of that shaft, in order that air should be obtained.

3736. Will you explain to us the philosophy of a smoky chimney?—I think it is entirely the want of power in the ascending column of heated air to counteract the effect of the wind on the top of the chimney, or of a counter current below, or both.

3737. Does not a part of the smoke go up one side, and a part of the smoke descend on the other side, and come into the room?—Yes; if the wind acts on the top of the chimney, and forces the column of heated air down the chimney; or if it comes into the room otherwise, I think you will find that is from a counteracting effect in some other part of the house of a greater power than the column of heated air in the chimney.

3738. Is it not the fact that you see the smoke going out at the top of the chimney and coming down into the room?—No doubt you do. All this in theory is well enough, but I humbly submit that it would be a fallacy, tending to destroy all practical utility of such an inquiry as this if any weight whatever was placed on the natural brattice. It can only take place under extraordinary circumstances, and to an extent which is perfectly inapplicable to anything in the shape of ventilation.

3739. But is it a matter of theory if you cannot obtain a sufficient amount of ventilation by means of a furnace, in consequence of the furnace limit?—The natural brattice is immeasurably behind the power of the furnace; it ceases when the furnace begins to operate; any power of that kind which is immeasurably below the power of the furnace, cannot have any practical operation. In 40 years' practice I have never experienced anything like a natural brattice in ventilation.

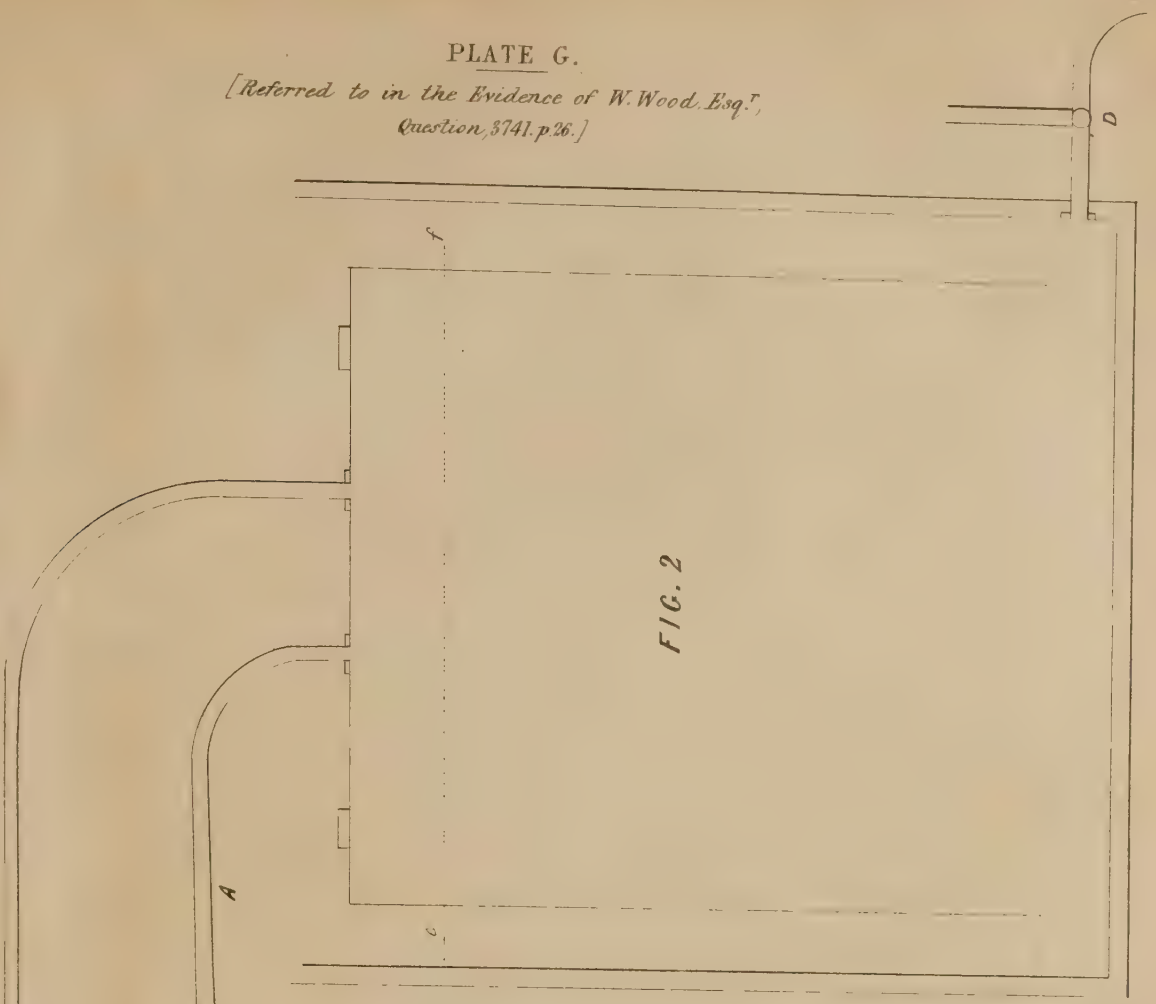
3740. *Chairman.*] Since the Report of the Committee of 1852, have you turned your attention more particularly to the subject of safety-lamps?—I have; I found considerable doubts existed as to the safety of the Davy lamp.

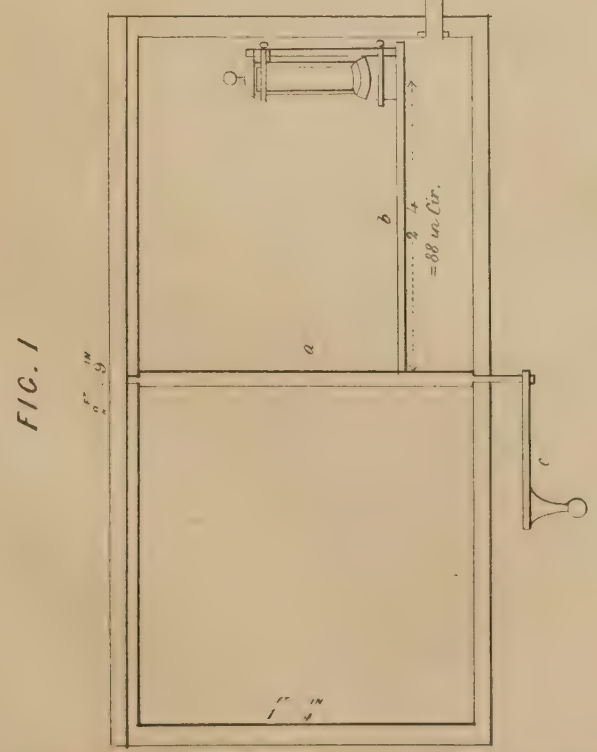
3741. In consequence of that did you make some experiments to ascertain at what point of velocity all the lamps that you knew of would explode?—I did; I had before on previous occasions, along with the late Mr. George Stephenson,

and

PLATE G.

[Referred to in the Evidence of W. Wood, Esq.r, Question, 3741. p.26.]





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and subsequently by myself, made a great many experiments to ascertain if it were practicable to pass the flame of fire-damp through the wire gauze. I was never able to do so. In those experiments the air was made to act on the lamp either by blowing the air upon it with a bellows, or by moving the lamp in a rectilinear motion; and although we got the heat of the wire gauze of the lamp to much beyond a red heat, still we were not able to pass the flame. I have thrown coal dust upon it in that state, and still was not able to pass the flame; and I have also thrown oil upon it, in a state a little above red heat, and I never was able to pass the flame through the meshes of the lamp. I then had an apparatus made, shown and described in Figs. 1 and 2, Appendix, Plate G. Fig. 1 is a box 2 feet 9 inches square, and 1 foot 4 inches deep, with an upright spindle *a*, on which is fixed the arm *b*. On the spindle outside the box is a handle *c*, and on the arm *b* the lamp is fixed as shown. Fig. 2 is a gasometer which is filled with gas by the pipe B from the blower, the pipe A conveying the gas from the gasometer into the box Fig. 1. D is a cock for letting water into or out of the cistern in which the gasometer is placed. When the cistern is filled with water up to *e f*, the cock D is opened, the water is emptied out of the gasometer, and it is filled with fire-damp, receiving the pure gas by the pipe B, and the atmospheric air by the pipe A; when filled with gas of the proper mixture, the cock is turned, the water rises in the gasometer, and forces the gas into the box by the pipe A, and the lamp is turned round with such a velocity as may be required, being immersed in the inflammable mixture. This was placed near a blower in the Killingworth Pit, a blower that had been discharging gas for about 12 years, and different descriptions of lamps, to the number of 12, were placed upon the arm within the box, and turned round at different velocities until they either went out, or until the gauze of the lamps attained a white heat, and they exploded through the gauze.

3742. Was the gas in the box in as highly explosive a state as any gas that you would find in a coal mine, that would cause any serious explosion?—The mixture was kept as nearly as possible to that of one of fire-damp to seven or eight of atmospheric air.

3743. That being the most dangerous mixture?—That being the most explosive mixture, according to the experiments of Sir Humphry Davy. Before giving the details of the experiments, I should state that the lamps experimented upon were of two principles of construction. One, the safety of which depends entirely upon the wire gauze, such as the Davy lamp, and other lamps, the cooling property of the wire gauze being the principle of safety; the other principle being that of the admission of a limited quantity of atmospheric air within the lamp, the security and insulation of the lamp being attained by glass or talc. Taking the Davy lamp as the test of lamps, the safety of which depends entirely upon the cooling power of the gauze, I found that, when subjected to an explosive mixture, so long as the wire gauze of that lamp was below that of a white heat, even although it was subjected to a velocity of 12 feet a second, it did not explode. But when the heat reaches a brilliant white heat, and with a velocity of about 15 feet per second, the lamp exploded.

3744. Mr. *Cayley*.] What pace is 15 feet per second?—About 10 miles an hour. When the lamp was placed in an inflammable mixture, it soon became of a dull red heat, and I found that the heat when the lamp was stationary did not increase. When the lamp was moved, being in that state, at a sudden or rapid velocity of about eight or ten feet per second it went out; and it was only when it was put into motion with a very gradually accelerating velocity that the heat could be raised above that of a red heat without putting the flame out.

3745. Accelerated from what?—From rest up to the required velocity. If the velocity was sudden it put the lamp out; but if the increasing motion was gradual, so as to gradually increase the heat of the wires, then a white heat was acquired; but it was with extreme difficulty that in any of the lamps the wire could be got above a red heat without the lamp being extinguished. I will presently give the effect of experiments of the lamp being moved horizontally, and not in a circular motion.

3746. *Chairman*.] You made experiments, you say, on the two kinds of lamp; did you get the glass lamps to explode as well as the common wire gauze lamps?—The glass lamps, being on the principle of an admission of a diminished quantity of air to feed the flame of the wick, all these lamps were put out when inserted in an inflammable mixture and when put into motion. In the Davy lamp, when

the flame leaves the wick, (which is always the case when the lamp is placed in a pure inflammable mixture,) there is a sufficient quantity of inflammable gas to continue combustion, independently of the flame of the wick of the lamp; but in all the lamps with a diminished quantity of air admitted, when the gas becomes so pure as to burn itself without the aid of the flame of the wick, then it leaves the flame of the wick, and it goes out immediately. Directly the gas is admitted into this lamp (*producing a glass lamp*), the flame elongates, and so burns with a very great length of top. Then, when the inflammable mixture is increased in purity, and the quantity of oxygen diminished, it assumes a state of combustion of gas alone; without the aid of the wick, and directly it acquires that state, the lamps admitting a diminished quantity of air go out. But in the Davy lamps, and those glass lamps having a wire gauze top, there is a sufficient bulk of inflammable mixture admitted within the gauze, independently of the flame of the wick, to support combustion; and therefore the Davy lamp, and all those lamps with wire gauze, do not go out; and therein consists the danger of explosion in case of velocity. We have a cylinder full of gas in a state of combustion, and by giving the lamp the motion described previously, the gauze is gradually heated, the cooling powers diminish, and, when the wires are in a state of white heat, the flame passes.

3747. Did you try any lamps with copper wire gauze?—I tried the Clanny lamp with a copper wire top.

3748. Did you find that the copper wire would melt before the gas would explode?—I found that when the copper wire was subjected to the same heat as the iron wire, that the wire melted and broke through, and formed a hole in the side of the lamp. I could not ascertain the temperature of the flame within the cylinder when the copper wire melted; but it melted at a heat below that at which the wire gauze did not pass the flame.

3749. That being your opinion, do you not think that the use of copper gauze should be altogether done away with?—I think the use of copper gauze very dangerous, inasmuch as the copper has not so great a cooling property as iron wire. This was distinctly pointed out by Sir Humphry Davy in his experiments; but still I find some lamps made use of with copper gauze.

3750. I believe you tried the Eloin lamps, as well as the lamps having glass and gauze too?—I did.

3751. Did you explode the Eloin lamp?—The Eloin lamp did not explode. We could not explode the Eloin lamp or the Stephenson lamp when the glass was within and covered the gauze.

3752. The Stephenson lamp having a glass from the top to the bottom of the tube?—Having glass from the top to the bottom of the cylinder of gauze, the air admitted in a diminished quantity at the bottom goes out. All those lamps with a glass insulation and with a copper top, or where the glass covered the gauze, did not explode; and the lamps where the glass is used which did explode, was the Clanny and such lamps having wire gauze tops.

3753. Any lamp so constructed, such as the Glover lamp, or Boty lamp, or any lamp having a glass below as a shield to the wick, and a gauze above, unprotected by glass, you could explode?—Any lamp with a cylinder of wire gauze above, unprotected or partially protected, exploded.

3754. Therefore, in lamps so constructed, you have two causes of danger: you have, first of all, a danger of the glass cracking, and leaving the lamp unprotected around the wick; and you also have the danger of explosion, in consequence of the unprotected gauze?—Yes; I made some experiments as to the size of wire gauze that would explode. The Clanny lamp has five inches of wire gauze upon the top of it, and it exploded more readily than the Davy lamp.

3755. You mean a height of five inches?—A height of five inches; and the cylinder being larger than the Davy lamp it exploded sooner than the Davy lamp. Then, as to the Stephenson lamp, the glass being removed, and it being also about seven inches long and of a larger diameter, the cylinder of gauze there also exploded sooner than the Davy lamp; the tendency to explode being in the proportion of the quantity of gas contained within the cylinder of gauze. Then, I exploded the Boty lamp, which is a Belgian lamp, very extensively used I believe in Belgium. The cylinder of gauze in it is about four inches long and about an inch and a half diameter. Although that lamp is on the principle of a diminished quantity of air with a glass light, yet the quantity of wire gauze used at the top exploded in the same way as the Davy lamp.

3756. Did that explode at a lower or higher velocity than the Davy lamp?—About the same.

3757. The diameter of the wire top being the same?—It being shorter than the Davy, the diameter a little more, but in the aggregate containing a less quantity of gas in the inside. Then I exploded a lamp called the Jack lamp, which is a Davy lamp with a glass shield upon it; a cylinder of glass put upon it, as a glass shield.

3758. The lamp you now produce to the Committee is the Jack lamp?—Yes.

3759. Having a shield of glass from the bottom, of how many inches high?—Three inches, and leaving about three inches and a half of gauze exposed; and that lamp also exploded. It is necessary to observe that the shield ordinarily used in a Davy lamp is no protection against explosion, under the circumstances which I have shown; it is a protection to the flame of the wick, but it is no preventive against explosion.

3760. The reason being, that the whole lamp becomes filled with inflammable gas, and explodes above the protective shield of glass?—Yes.

3761. Mr. *H. A. Bruce.*] Does the Davy lamp, partially shielded, explode as soon as when not so protected?—Not quite so soon, the quantity of gas being, to a certain extent, diminished; but the shield on the Davy lamp is placed near the bottom of the lamp; and on observing the appearance of the lamps which exploded, the greatest heat is apparently near the top, or about two-thirds of the height of the lamp, the shield being at the botton, does not, therefore, protect the lamp in that part where it acquires the greatest heat.

3762. How long was the Davy lamp exposed to the velocity to which you subjected it before it exploded?—The first experiment was after the lamp became red hot, and was moved round until it got into a higher degree of heat than could be possibly acquired in practice, up to 10 feet velocity per second; it was then subjected to 160 revolutions of 7 feet 4 inches each, and continued for 116 seconds, and it did not pass the flame; in the next experiment it was moved 1,460 feet in 114 seconds, with a velocity averaging 11 feet per second, and it did not pass the flame, although it was got up to a very great degree of heat.

3763. *Chairman.*] The lamp at that time being only red hot?—The lamp in those cases getting up to a white heat, and being moved by the operator at as great a velocity as he could produce. Then by first of all getting the lamp up to a state of white heat, and then applying the velocity at the rate of 15 feet per second, it required 60 revolutions, or 440 feet, at that rate, of 15 feet per second, before it passed the flame. The next experiment did not pass the flame until it acquired a velocity of 19 feet per second. The Stephenson lamp, without the glass, passed the flame at 14 feet per second; the Clanny lamp, with the copper gauze, passed it at 12½ feet per second; and the Clanny lamp, with the iron-wire gauze, at 16 feet per second. Then I tried a lamp with a shorter gauze, of only 2½ inches in height, and it exploded; and also the Eloin lamp, with a wire gauze substituted instead of the glass, of only two inches in length, and two inches diameter, and that quantity of wire gauze, when at a white heat, exploded.

3764. Did you try Dr. Fife's lamp also?—No, we did not on the second day.

3765. Had you any reason for not trying it?—We tried it the first day, but it went out when placed in the inflammable mixture, and we could not raise the temperature so as to produce a white heat; and I could not get a lamp the second day with which to make the experiment. I tried Dr. Glover's lamp, which is a lamp with a double glass, the air being admitted between the glasses, and so passing into the interior of the lamp; this lamp has a wire gauze top four inches in length, with a short chimney in the inside of it. I subjected that lamp to a considerable velocity; we could not produce a white heat, and the flame did not therefore pass; it went out, although the wire gauze was much longer and of larger size than that of some other lamps which I had exploded; but I attribute this to the chimney in the inside of it diminishing the area of wire gauze and burnt air for the wick, cooling down the explosive mixture within the gauze. I am, however, of opinion that the construction of this lamp may be improved, as I see no reason why the insecure gauze should be placed on the top. I think those experiments all show that, with lamps having a diminished quantity of air passing into the inside and so feeding the wick, and with the use of glass, there is no occasion to have the insecurity of the wire gauze upon the top of the lamp.

3766. In point of fact, in that case you have a double insecurity; you have the risk of the glass breaking, and you have also the insecurity of the wire gauze at

the top?—You have two insecurities. Now the Eloin lamp is not so constructed; it is constructed with a copper chimney, and hence only the insecurity of the glass. I believe the objection to the use of a copper chimney is, that the flame heats the chimney very much, and Dr. Glover informs me that he had made use of a copper chimney at first to his lamp, and it was objected to as being heated too much; and he therefore substituted the wire gauze. I think, in the case of Dr. Glover's lamp, if the wire gauze were made of a smaller diameter, and if his chimney of copper was carried nearer the top, it would then be extremely difficult to pass the flame through the wire gauze, and it would be a safer lamp. Probably it may be necessary that, in the chimneys of such lamps, a radiating chimney better than a cylinder of copper should be used, a double wire gauze would be better and more safe than a single one, and would radiate the internal heat. Dr. Fife's lamp has a double wire gauze, and his lamp is on that account safer than a single wire gauze top; he uses talc instead of the outer glass of Dr. Glover. I think, so far as regards the comparative security of glass and talc, with double cylinders, there is not very much difference in them.

3767. Practically speaking, is talc a good substitute for glass?—Not for a single glass; I think not; but as a protection to an inner glass I think it is; although the objection against it is, that it is opaque.

3768. Mr. *Cayley*.] You spoke of the apertures being insufficient, as I understood you; that the gauze was too coarse in Dr. Glover's lamp?—No, my objection was to the single gauze, which is, like all cylinders of single gauze, liable, under certain circumstances, to pass the flame.

3769. What is the number of meshes?—I think the whole of the gauze lamps are 784 to the square inch.

3770. *Chairman*.] Is that the number most approved of by Sir Humphry Davy?—That was most approved of by Sir Humphry Davy. I believe in some lamps the number is rather less, the wire being made a little stronger; but the size of the apertures is the same.

3771. Is that beneficial or otherwise?—I believe in practice it has been rather considered to be beneficial, inasmuch as it makes a stronger gauze, care being taken that the apertures are not enlarged in consequence.

3772. Have those experiments brought you to any result as to the superior excellence of any one lamp over all others?—I think, as a wire gauze lamp, the Davy lamp is the most secure, as being the most simple, the objection to it being the great length of gauze exposed to the current of air in case of motion. I think a lamp with a shorter gauze a little larger in diameter, to obtain a better light, and protected by a cylinder the whole height of the gauze, might be a safe lamp. The great objection of the colliers against the Davy lamp is the want of light, and consequently the attention of inventors of lamps has been directed to getting a lamp of a larger diameter with a larger light, and, like Eloin's lamp, with an Argand burner.

3773. Mr. *Cayley*.] What do you mean by larger diameter?—You cannot get a larger light in the inside of a lamp unless you increase the diameter of the lamp.

3774. You mean the diameter of the lamp, not the diameter of the gauze?—The diameter of the lamp where the light is placed. All those lamps are enlarged at the bottom, to obtain a better light than the Davy.

3775. *Chairman*.] That lamp in your hand is an Eloin lamp with a wire gauze and shield to it?—Yes, this lamp is the lamp I tried, an Eloin lamp, substituting gauze instead of glass, and protecting that gauze by a shield of talc.

3776. Did you try to explode it?—No; we did not try it. It would be impossible with a lamp of this kind for the air to strike upon it so as to increase the intensity of the flame so as to produce a white heat, the entire height of the gauze being protected.

3777. Looking to the question of light as well as to the question of safety, have you come to any conclusion as to any lamp being superior to all the others; or can you suggest any improvement which would combine the two, and so make a lamp that would be superior to all?—Mr. Hall, of Newcastle, is at present engaged in making a lamp which we tried, and which did not explode. It has a double gauze top and is constructed in a very ingenious way with reference to the admission of air; he has not perfected it yet, but I think it may probably be a very good lamp. In my opinion, Dr. Glover's lamp is likely to be a very useful one. The objection to all glass lamps is of course the brittle nature of the glass. Stephenson's lamp is the safest of all glass lamps, having the security of the gauze

when

when the glass is broken. The double glass of Dr. Glover also adds to its safety. When this lamp was subjected to an inflammable mixture, I had the apparatus so constructed that I could throw water against the glass, and that cracked the inside glass of the lamp of Dr. Glover.

3778. Throwing water on the outside glass of Dr. Glover cracked the inside glass?—Cracked the inside glass. I do not know how the water operated, but certainly the glass came out cracked from the experiment.

3779. From the rapid decrease of the temperature by the water?—From the rapid decrease of the temperature by the water, I presume; the outer glass is also cracked, but I think it had been done by other means than by the water.

3780. Mr. *Child.*] Would it not be probably the contraction of the metal that cracked the inner glass?—It might be; I believe they find in the Clanny lamp that when the glass fits very tightly, and it is subjected to a great heat, the glass cracks from the increased temperature, and they have substituted a little ring of India rubber upon the top and bottom of the glass to allow for the expansion; and it may be that Dr. Glover's lamp had been cracked by the expansion of the glass, and not by the effect of the water.

3781. *Chairman.*] Did you try Mr. Henderson's lamp which was protected by water?—No, I did not try Mr. Henderson's lamp.

3782. That is of the same formation as Dr. Glover's, except that distilled water, or water of some kind, is kept always between the two glasses; in your opinion, would that increase the safety of the lamp?—I could hardly say what effect the great heat would have upon the water in the inside of the two glasses, not having tried it; but I see that this lamp has the same objection that all those other lamps have, namely, having an unprotected cylinder of gauze upon the top, and without any chimney. This is a Clanny lamp (*showing a lamp*), which was subjected to intense heat; it had passed the flame and was afterwards put in the inside and subjected to the experiment of water thrown upon it; the effect of the water upon the glass was to crack it very much, but it did not throw off any part of the glass; it was afterwards subjected to a very high degree of heat, and moved at the rate of something like 12 feet a second, and it did not explode notwithstanding those cracks.

3783. Dr. Fife's lamp, being protected by talc, would probably not crack under those circumstances?—Probably not; the outer talc cylinder being a protection to the inner one.

3784. Mr. *Child.*] Did you try it?—We tried it the first day, in the same manner as the other lamps, but we could not succeed in getting the gauze up to that degree of heat to explode. It has a top the same as Dr. Glover's, and the same as the others which have exploded; but it has a double cylinder of gauze, and certainly in the experiment we could not succeed in passing the flame through the gauze; the wire was never up to that degree of temperature that would pass the flame. Whether it was from the double gauze upon the top or not, I do not know; but I am decidedly of opinion, that if a top of wire gauze is to be used at all, it should be a double wire gauze.

3785. Did you try Dr. Fife's lamp with water, to see whether the glass would crack?—No.

3786. *Chairman.*] But you have not come to any determination in your own mind, whether a metal top of some kind should not be substituted for the wire gauze, whether single or double?—I think that, in all glass lamps, the top should be made, either of some metal of great radiating power, so as to rapidly diminish the temperature and so to render it inexplosive, or with a double wire gauze top; we have in the glass lamps the insecurity of the glass, and no doubt the lamp with two cylinders is safer than with one. Therefore a lamp with a properly constructed top, upon the principles I have explained, with two cylinders of glass, is the safest lamp.

3787. At present your opinion is, that Dr. Glover's combines the two principles of giving the greatest quantity of light, and the greatest safety, more than any other lamp that you have seen?—I think Dr. Glover's is the best lamp of that construction I have seen.

3788. Mr. *Cayley.*] With two cylinders of glass?—I think two cylinders of glass are better than one cylinder. The substitution of talc instead of glass secures you the light, but there is no greater security in talc than in glass.

3789. *Chairman.*] Have you seen the lamp sent by Mr. Thornton this morning, stated to be an improvement upon the Eloin lamp?—It is an improvement, so far as

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as the addition of a cylinder of talc around the glass goes; but then there is the disadvantage by the diminution of the light occasioned in consequence of it.

3790. All those experiments were made by moving the lamp round in a circle with a very rapid motion, were they not?—They were.

3791. You stated that you would give the Committee an account of some experiments made on a lamp moved in a backward and forward horizontal direction; will you be kind enough to do so?—I will give in the Appendix the whole experiment.

Vide Appendix.

3792. Will you state shortly the results?—The mode of conducting the experiment was by a box 12 feet long and 18 inches square, with a groove within, on which a slide was placed. The lamp was put upon the slide, then a cord was attached to the slide working round, a roller at each end of the box; one end of the cord coming out on the outside. The box was filled with inflammable gas from the gas issuing out of the Wallsend Pit, and the lamp being placed upon the slide it was kept in that state until it was red hot; it was then moved by the cord and the slide at a rapid motion from one end of the box to the other, alternately backwards and forwards, and the result of the experiment was this: I should observe that these experiments were made by Mr. Thomas John Taylor, assisted by Mr. Clark, of Wallsend, and the engineer, and wasteman, and others. The first lamp used was the common Davy lamp. It was moved backward and forward, after being red hot, at the rate of from 10 to 12 feet per second, and the flame did not pass. A greater speed than that was tried, and the lamp was extinguished by the inequality, I presume, of the motion..

3793. The lamps being then only in a state of red heat?—The rapid motion produced more than a red heat, but still not to that degree of heat which my experiments proved that the flame passed. Then the experiment was repeated two or three times, and it was found impracticable to pass the flame through the lamp, the velocity acquired being about 12 feet per second, and then the lamp was jerked backwards and forwards with great violence, as much as could be done, and they found it quite impossible to pass the flame. The Stephenson lamp was experimented upon with the glass in it, and it was extinguished. Museller's lamp was tried with the same result. Then the Clanny lamp was tried, but it was extinguished at a lower velocity than Davy's; Glover's lamp was also tried and went out, and the Eloin lamp was also experimented upon, and also Upton and Roberts's lamps.

3794. Mr. *Ingham.*] Did Upton and Roberts's and the Eloin lamps go out?—They went out.

3795. *Chairman.*] Did any of them explode?—No, they did not explode. Those trials corroborate the previous experiments I had made on rectilinear motion. (*Mr. Martin Roberts's lamp was handed to the Witness.*) I have examined this lamp, which is a very ingenious construction. The way in which it differs from the other lamps, is by its having an apparatus to extinguish the light in case of the glass being broken. There are two glasses, the space between which is filled with water; and that water presses against an India rubber spring or disc, which sustains an extinguisher within the lamp. If by any accident the glass is broken the water escapes; and the pressure being removed the disc expands and throws the extinguisher down on the wick, and so puts out the lamp.

3796. Do you apprehend that the size of that would be any objection to it?—I think the size of it might be very much diminished. I presume the size might be made something like the same as the other lamps. You have in this lamp the security of the flame being put out in case of such an accident, and against that a little complication of machinery.

3797. Will you proceed with the explanation of your experiments?—The experiments of Mr. Taylor corroborate all the experiments I had previously made, viz., that I think it is quite impracticable to produce that state of white heat in either the Davy or any other of those lamps in practice, by rectilinear motion, that would pass the flame.

3798. You stated that in order to bring the lamp up from a red heat to a white heat, it was necessary to move it round very gradually; will you tell the Committee whether any circumstances likely to occur, in any mine, would operate in that way; for instance, first of all take the circumstance of a lamp being filled with inflammable gas and being red hot in a state of rest; would the constant burning of the gas in that lamp ever bring it to a white heat?—I think not; the practical operation of that is this, that it attains the maximum degree of heat

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in a very short time; as it is continued in the inflammable mixture, the combustion of the gases and smoke dulls the lamp; and there is not so large a quantity of gas admitted within the lamp, which rather diminishes the heat than otherwise while remaining still. I do not think, therefore, by allowing the lamp to remain in an inflammable mixture at rest, it could by possibility pass the flame.

3799. But at the same time you do not approve of working with a lamp full of gas for a long time?—Certainly not; the orders in all the collieries are, or should be, that immediately the workmen see the presence of gas in the lamp they are to withdraw it, and that they should not by any means allow it to become in a state of red heat; I think it is very necessary that those orders should be given in all collieries that use the lamp, and that those orders should be enforced, because it is always necessary that you should keep very far within the limits of danger. Certainly it should be made imperative to remove the lamp, in case it becomes red hot.

3800. It has been stated by one of the witnesses before this Committee, that there might be danger arising from a man getting alarmed, and losing his presence of mind on finding the lamp full of fire-damp, and becoming red hot, and from then taking his lamp into a current of air, and moving very quickly; is that your opinion?—I think the experiments show that a rectilinear motion, if that motion is not extended beyond 10 or 12 feet a second, after the lamp is completely red hot, does not pass the flame; but keeping in view that practice which is most safe, certainly the instructions to the workmen should be, that they should move the lamp as quietly as possible.

3801. And cover it, if possible, with their jackets?—That is rather a dangerous process. It is done in some cases, but it ought to be deprecated; because, if the lamp is in a state of red heat, and you cover it with a cotton or woollen or any such substance, it may fire the threads of the cotton or woollen on the outside; therefore it is dangerous. It is less dangerous to remove the lamp quietly, than to endeavour to put it out.

3802. But at the same time the man should carry it before him, so that his body should act to prevent the current crossing the lamp at a rapid rate?—If he carries it before him, as he generally does, then he would in some degree shelter the lamp; but I think after those experiments attention should be directed to sheltering the gauze more effectually than has hitherto been done. It seems quite clear that the Davy lamp is unnecessarily long, and that that lamp may be constructed of a less length of gauze, and shielded so as, in case of becoming red hot, the velocity of the motion of the man or of the current would not make it dangerous.

3803. Have you any doubt that a lamp might be constructed that would combine as near as possible perfect safety, and the giving at the same time abundant light to the workman, at a reasonable cost?—I have not. I am not an advocate for the Davy lamp being increased in diameter, so as to give additional light; as you cannot with the common Davy lamp give additional light by an increased diameter, and have the requisite security. But if you use glass lamps to give the necessary light, then I think the construction of those lamps should not be such as to add, in addition to the insecurity of the glass, the insecurity of single wire gauze upon the top; and it would be very well if some substance could be employed that is not liable to break when subjected to water. Though, in the case of all those lamps with glass, when subjected to water, and at the highest degree of heat that I could possibly acquire in the experiment, the water being thrown upon them in that state of heat only cracked the glass, but they were still safe.

3804. Is it the fact that the Davy lamp is the quickest test, and shows the presence of fire much more quickly than any of the other lamps?—It shows it more apparently, a larger quantity of gas going into it; but a very nice observer may see the appearance of the gas upon all those lamps almost at the same time: I had them all placed within the box (Fig. 1, Plate G., Appendix), and let in the gas gradually, so as to ascertain which of them shows the gas first: I think it was seen in the Davy lamp first, the Stephenson next, and so in proportion with those lamps which admitted the largest quantity of air. And the lamps went out according to the same principle; those lamps which admitted the largest quantity of gas were longest in going out.

3805. Looking at those experiments you have made, do you agree with the Report of the Committee of 1852, that where a proper degree of ventilation does

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not exist in a mine, the Davy lamp, or any modification of it, must be considered rather as a lure to danger than as a perfect security?—Those experiments have increased my confidence in the use of the Davy and those other lamps, inasmuch as I know now the circumstances under which they become unsafe, which I did not before; and having heard from even practical men that, under certain circumstances, the lamps were unsafe, and finding now that, under those circumstances, they were perfectly safe, I have more confidence in the use of them than I had previously had; and also, seeing that those circumstances are such as ought never to occur, and which I think scarcely can ever occur in a coal mine, under any circumstances, I have now very great confidence in their security.

3806. Those being your opinions, would you make it imperative by legislative enactments that in all fiery mines the safety-lamp should be used?—I think it would be desirable that some rule should be laid down by which the use of safety-lamps should be regulated; but I could not go so far as to say that in all circumstances a lamp should be used in a fiery mine, because in some mines producing gas, candles may be used with perfect safety.

3807. Would you then give the inspector of the district a discretionary power to order safety-lamps to be used in mines, if he thought it necessary?—I would wish hereafter to suggest to the Committee that a code of rules or regulations should be adopted, which should act as the instructions of the inspectors, and one of those rules certainly should be that there should be a discretion with the inspectors to order the use of safety-lamps under certain circumstances. But then I think those circumstances which cannot be made general, or comprised under any general rule, would necessarily vary, and ought to be left to the discretion of the inspector under certain conditions.

3808. However highly you estimate the safety-lamp, your opinion is that the first and most material point to attend to in the safety of the mine is ventilation?—The first thing is, to adopt that system of ventilation which gives the largest quantity of air; and then, having got the air, that you should distribute it in the mine in the most judicious manner, and so, as a general principle, that every mine should be made as safe as it is practicable to make it. Then, if that is not sufficient, to dilute and discharge the gas with perfect safety, and the mine continues in a state of insecurity, I think it should then be imperative that the safety-lamp should be used. Before I leave the subject, I have omitted to mention two very important experiments we made in the progress of this inquiry, which were with reference to throwing coal dust upon the lamp when it was in a state of red heat; one of the experiments we made upon the Davy lamp, and the Clanny lamp, and some others, was to put the wires of the lamp into the greatest possible heat that we could get them into. When in that state, with a pair of bellows we blew in coal dust upon it; the appearances of the lamp within the box was such as almost to induce us to believe that it had exploded, but the explosions were confined within the wire gauze and did not pass outwards. We blew in dry coal dust upon the lamp in a state of white heat, and it did not pass the flame; we then rubbed the wires so covered with dust with oil, and also during the time the lamp was turning round in that state, poured oil upon the lamp, and we did not succeed in passing the flame.

3809. When you say the lamp exploded, do you mean that it exploded the whole of the gas within the box?—Yes; when I say it passed the flame, I mean it exploded the gas within the box; and the top of the lid being loose the explosion blew the lid off the box.

3810. Supposing such a state of things should exist as to make it necessary to enforce the use of safety-lamps in a mine, is it your opinion that those lamps should be inspected, cleaned, and repaired by one man at the top of the pit every day?—I think, as we have in the north stations near the bottom of the pit, or at such a distance from it as that candles can be used with safety, there should be a station beyond which the candles are not allowed to pass; a man should be placed there to examine all the lamps, and no lamp should be taken beyond that station without having been thoroughly inspected. The workmen should have orders, in case the lamp goes out, to return to the station to have it relighted and re-examined; but the orders in all the collieries in which lamps are used, should be that no lamp is to be passed beyond the lamp station without being thoroughly examined.

3811. Would you allow the colliers to take their lamps home at night to clean them?—The general practice is for the collier to take the top of his lamp home

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to clean it, but then he has to return it in the morning to the person at the station, who keeps the bottom of his lamp there.

3812. That person is capable of examining it to see that none of the meshes of the wires are defective?—He is a person that is considered capable of examining the wires, and detecting anything that is wrong in them.

3813. Would you give the collier the key to open his lamp, or would you keep the lamp locked?—Certainly not; the collier should not be entrusted with the key at all.

3814. Have you ever known any instances of accidents happening from the carelessness of workmen taking the tops off their lamps?—I have known instances of explosions from colliers taking the tops of their lamps off; I believe they do so generally, from a conviction that there is no danger to be apprehended, and though the workmen are generally careless they would not I think do it, except that they think there is no danger in doing so.

3815. The reason of their so doing would be that they could not get sufficient light from the lamps?—I think not much for that object; it is generally from wanting to take it off to smoke, or thinking that the mine does not require lamps.

3816. Where safety lamps are used would you allow the collier to smoke?—No, certainly not; smoking is prohibited in mines where lamps are used.

3817. Would you allow him to use gunpowder at his own discretion?—No, certainly not; I think where lamps are used no gunpowder should be used, except by the direct strict authority of the over-man, or some accredited person, and then it should only be used in cases where the mine is generally considered to be perfectly safe without the use of safety lamps, and where lamps are used only as a security against sudden outbreaks of gas. I think, in a mine that is doubtfully safe, safety lamps should be used, and gunpowder should be prohibited; lamps should be used where the mines are liable to become unsafe by any sudden outbreak of gas.

3818. In those regulations you have alluded to, I dare say we shall find this point touched upon?—Yes, it will be particularly noticed.

3819. Mr. *H. A. Bruce.*] You mentioned that the increased confidence you derived from the result of your experiments arose from two circumstances: one was, that the lamp could not be made under ordinary practical circumstances to attain the same amount of heat: and the other was that it could not under ordinary circumstances be made to move at the same velocity as that to which you subjected the lamp in the experiment?—I found that no velocity, unless it was kept up for a considerable period, and was likewise an accelerating velocity, would bring up the lamp to that state of heat which would pass the flame; and I think that it would be extremely difficult in practice to produce the circumstances requisite to get it to that state of heat. The miner would have to put it very gradually into motion, and would have to keep it at a gradually increasing velocity, and then to acquire an ultimate velocity of at least 15 feet per second; all of which could only be done wilfully.

3820. The velocity you mention as having been reached when the Davy lamp exploded was 15 feet a second in 60 revolutions?—In 60 revolutions of 15 feet per second, after being in a state of white heat.

3821. That speed could hardly be reached by a person running under the circumstances suggested by a former question?—I think not.

3822. Mr. *Cobbett.*] With respect to taking the tops off, I suppose you agree with the rest of the witnesses that the miners ought not to be allowed to take the tops off their lamps?—Certainly; they ought to be locked with a very secure lock; there has been a great improvement made in locking lamps lately, in a way in which the miners have very great difficulty indeed in opening them.

3823. Will you be so good as to explain what you mean by taking the top off?—The whole cylinder (*describing the same*), that is, the top of the lamp, is unscrewed from the bottom, and so exposing the light.

3824. Mr. *Locke.*] You have had, of course, a great number of years' experience in these lamps; have you ever arrived at the notion yourself that they were unsafe?—I stated in my evidence, in 1852, that I had never experienced a case in which I knew a lamp explode.

3825. A question was put by the Chairman just now, with reference to the report of the Committee last year. You say since you have made certain experiments, your confidence in the lamps has been increased. What I wish to know

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know is, whether, before those experiments were made, you had ever entertained any very serious doubts of the fair security of these lamps?—Never; I never had any doubts of their security. I have gone myself into places very frequently which were dangerous, and the use of them by thousands of workmen has been to me a proof of the security of them; and certainly there have never come under my notice any well-authenticated cases where lamps have exploded.

3826. Then I collect that it is your opinion that the fair use of those lamps, instead of being a source, or rather a lure to danger, might lead, and would lead, the workmen to avoid situations of danger?—I think it is very necessary that the workmen should be instructed as to when the lamp does really become dangerous. Keeping the rules far within the limits of danger, I think, would rather have a tendency to induce security than to add to danger.

3827. *Chairman.*] Do you know of any instances of explosions from naked lights, which could not have taken place if attention had been paid to the use of the Davy lamp?—Yes.

3828. Do you know of many?—Yes.

3829. Will you state to the Committee whether you approve of the present system of Government inspection?—I think that the present system of inspection is not conducted upon a proper basis with regard to the object in view.

3830. Do you approve of the employment of Government inspectors?—I think it is necessary now that Government inspectors should be appointed. With reference to the mode in which that should be carried out, I would begin, in the first instance, by going into the state of the management of the mines before going into the system of inspection; that is, we should know the evil before we attempt the cure.

3831. Perhaps you will describe to the Committee the system and schemes of management in the best-conducted collieries in Northumberland and Durham?—I think the present state of the management of the coal mines in this country, which I presume it is the object of the Committee to grapple with, is shortly this: Brought about by having to deal with mines of a very fiery nature for a long period of time, probably the management of the mines in the counties of Northumberland and Durham is the most perfect of any other district in the country. The mining engineers have had to deal with extremely fiery mines, and the mines being of a very great extent, they have had to meet all the different contingencies arising from fire, and all the other sources of danger and ventilation; and I would shortly state what is, I think, the general system that is practised in those counties, taking a large colliery or number of collieries superintended by persons of extensive experience. The superior person is what is called the *superintending viewer*; he generally looks after two or three or more collieries. At each of those collieries, if distant from the place at which he resides, he has under him what is called a *resident viewer*; a person of great practical experience, and generally capable of managing a mine without the assistance of the superintending viewer. The utility of the superintendent viewer being principally in having experience in several collieries, and bringing that experience to bear upon a particular one, and so assisting the resident viewers in the management of the mines. But the resident viewer, in all cases, is presumed to be a person who, apart from the superintending viewer, would, of himself, be able to manage a colliery. Where the superintending viewer resides at the colliery himself, he has not generally under him a person precisely of a similar capacity to a resident viewer of a distant colliery. The practice generally is to have an *under viewer*, who is a person going down the pit regularly every day and superintending the works, being a little inferior in standing to a resident viewer, but still a thoroughly practical man, and a man of education and character.

3832. Then these under viewers are capable of mapping and planning?—They are; they have a thorough knowledge of the system of ventilation, and everything connected with the management of mines. Then under these resident or under-viewers, as the case may be, is what is called an *overman*, whose duty it is to go down the pit every day and to inspect the state of the whole of the mine and the workmen employed in it; he has under him an assistant, who is called a *back overman*, who when he leaves the pit takes charge of it, so that it should not be left without a superintending person at any time within it. Then come what are called *deputies*, who are working men to keep the air-ways of the workings right, and put in the props and such things as those; there are generally five or six of them in proportion to the size of the pits; in some pits more than that, even

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as many in large pits as 12 of those men. Those men do everything relative to the working of the coal, the inspection of the working of the coal, and the putting the props in the workings, superintended by the back overman in the after part of the day, and by the overman in the former part of the day.

3833. Mr. *Locke.*] Are all those men well instructed in the use of the safety-lamp?—All those men are well instructed in the use of the safety lamp; they are men selected from the workmen from their superior knowledge and abilities, and are most generally men who have gone through all the different grades in working the coal; these all refer to the current working of the pit. In addition to those we have a set of men to look after the old workings and the old air-ways, and the air-ways not within the operation of working the coal at the current time.

3834. *Chairman.*] What do you call those men?—Those are wastemen who have charge of all the air-courses and everything in the pit: at each of the collieries there is what is called a *head wasteman*, who superintends the whole, and he has under him a *foreman wasteman* in each pit, and then this foreman wasteman has with him four or five, or whatever number is required of *working wastemen*, to keep the air-courses in proper order; so that at any moment of time the system of inspection is such that there is always in the pit some persons who have charge of what is going on, and who are compelled to see that everything is going on right. Now it may assist in determining upon the nature and amount of inspection required, to give a short epitome of the number of those people in the district of Northumberland and Durham.

3835. Mr. *Ingham.*] Do the wastemen attend to the air-courses in those parts of the collieries where the working is going on, as well as in the waste part?—No; the wastemen are for the purpose of looking after the air-courses that are not in current working; the deputies and the back overmen look after the air-courses in the current working part of the pit; I think generally there may be stated to be about 150 collieries and 300 pits.

3836. Mr. *Locke.*] Do you mean working pits?—In daily working; where coal is got.

3837. *Chairman.*] Quite irrespective of up-casts?—Unless the up-casts are not working pits; I mean in the pits at which coals are drawn. There are about 20 superintending viewers; about 120 resident viewers; about 100 under viewers; there will be 300 overmen, and 500 back overmen, because there is in some pits more than one back overman.

3838. The back overman is the same as the deputy?—No; he takes the duty of the overman in the after-part of the day; about 1,500 deputies, 150 head wastemen, and 150 foremen wastemen, and 1,200 wastemen; I merely state these numbers generally.

3839. What is the difference between the head wasteman and the foreman wasteman?—The head wasteman may have charge of three or four pits, but in each pit there is the foreman wasteman; the former is a superior class of person. Then the foreman wasteman goes along with the wastemen and works with them; altogether about 4,000 persons are employed in the superintendence of the operations of these collieries.

3840. That gives about 13 as an average to each pit?—Yes; the average will vary very much, but that is something like what is to be grappled with in case of inspection.

3841. Mr. *Locke.*] None of those men work coal?—None of those men work coal.

3842. They are all engaged, in point of fact, in the supervision and in the mode of ventilation?—The supervision of the working of the coal, the ventilation, and the security of the working.

3843. *Chairman.*] All of them have, more or less, according to their positions, superior knowledge of the working of the colliery?—All of them have a superior knowledge of the working of the colliery.

3844. Mr. *Locke.*] Is this irrespective of banksmen, of hangers-on, and of persons who have charge of the machinery?—Entirely; in addition there would, probably, be 800 banksmen in the whole of the collieries.

3845. *Chairman.*] In the midland and in the other mining districts, is pretty much the same scale adopted as to superintendents and other matters?—In some districts, within my knowledge, the superintendence is somewhat of the same nature, but that is, I think, extremely limited; I believe there is a very great number of collieries where the inspection is very much inferior, both in point of number and

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and of intelligence, to the persons superintending the mines in the districts of Northumberland and Durham.

3846. In the well-regulated mines is that so?—No; I think in the well-regulated mines of those districts the system is something like what I have stated; a little varied, not quite so many persons, but not much varied from the system that is adopted in Northumberland and Durham. I presume you will have other witnesses who are more acquainted with those districts than I am, and therefore I shall leave that for them to explain; but I know that, in a very great mass of the collieries, in the small collieries especially in the different districts of England, and Scotland and Wales, the management is very much inferior to that in Northumberland and Durham, and it is in those districts where I think the system of inspection is most required; and it is most required on this account, that those districts now are becoming what we were several years ago. When the mines in Northumberland and Durham were worked near the crops of the coal they were then comparatively free from danger to what they are now; they have been increasing in danger ever since, as the depth of the mines became greater, and the quantity of inflammable gas to contend with becomes also greater; the power of the machinery is increasing, everything being necessarily upon a much larger scale than formerly; that is in some degree now becoming the case with the other districts. There the crop is partly working out, and the mines are now being worked deeper; they are becoming more dangerous, and that is the state of things which is coming into operation with a class of managers not exactly of the calibre to meet those difficulties; consequently I suspect that a considerable number of accidents is attributable to such causes in those districts that I mentioned. I think, generally, in Northumberland and Durham, the number of accidents is diminishing. One of the coroners, Mr. Maynard, of the Durham district, has taken a great deal of pains to ascertain the comparative number of accidents now to what there were some years ago within his district, taken from his experience; and his conclusion is, that the number of accidents compared with the number of men employed is diminishing. If you go into the midland and other districts in Yorkshire, &c., you will find the number of accidents increasing, and I attribute that very much to the increasing difficulties and danger in the working and ventilation of the mines, and that the managers of those mines are not exactly competent to meet such difficulties; they were fully competent, probably, to manage the mines in their former state, but not quite so in their present state. I think there is a want of knowledge, and a want of intelligence in that respect, in a great number of the districts of the country. In several of them, I believe, the collieries are managed by the *owner*, having under him a *bailiff*, or *under viewer;* and where they are carried on by contractors, or butties, there is between the owner and the buttie in some cases only one person to look after the safety and the management of the mine. In some cases this person has in the larger collieries an assistant, an under bailiff; but generally in small collieries there is only, between the owner and the buttie or contractor, a bailiff or under viewer and an assistant. Now if you go to ascertain what class of persons those bailiffs are, I do not speak, of course, of the larger and better managed mines in those districts, but in a very great many mines you will find the bailiff very little, if anything, above the class of our back overmen, and they certainly do not come up to the overmen in our own district.

3847. Those men holding the same position as your under-viewers, not being of a better class of men than the back overmen?—They hold, in fact, the position of our superintending viewer, our resident viewer, our under viewer, and overman; there is not between the owner and the working man any person representing our superintending viewer, our resident viewer, our under viewer, or our overmen; all those classes of persons are wanting in the management of a great many mines in this country. Such being the case, it is a matter of very serious consideration in what way you can by any system of inspection lessen the number of accidents. I have already stated that I think several of the accidents that have happened have been occasioned by the persons in charge of the collieries not being competent for the management of them in their increasing danger and risk. I think all the information that we have derived from the observations made by the inspectors, and by the results of the coroners' inquests, tend to show that that is something like the correct state of things. Now I must very candidly state, that I think the system of inspection, as at present going on, is not what will under such circumstances bring about a diminution of the number of accidents; neither

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do I think that, if they were assisted by sub-inspectors, it would have any effect.

3848. We have heard the evidence of persons who were deputed by the colliers to come up here, stating that the colliers wished a set of sub-inspectors to be appointed under the present inspectors, which sub-inspectors should be practical colliers, taken out of the pits: in your opinion, would that be a system which would work beneficially or otherwise?—I think it would not work beneficially, and I will give my reasons for it. I think that the only thing that will diminish the number of accidents is, to bring to bear upon the management of the mines I have alluded to superior knowledge; even in the Northumberland and Durham districts I think a little increase of knowledge would not be a very bad thing; but I am quite sure it is absolutely necessary in other districts; and in my mind the only way in which accidents can be prevented is to bring about an increased knowledge, and a greater capacity and capability in the persons in the management of mines. I think the responsibility of the management of the mines must rest exclusively with the managers of them; I think inspection must be based upon other principles than that of interfering with, or even of seeing carried out, the working operations of the managers of mines; looking at the class of persons proposed to be appointed, such as the sub-inspectors are proposed to be, I think that they, having only to see that the under agents do their duty, is not the way in which the inspectors should be employed. I think it would take from the managers of the mines a considerable degree of responsibility, and I think it would lead to a great deal of cavilling between them and the persons they had to look after; because, if you consider the class of persons out of which those sub-inspectors are to be taken, out of the hewers or workmen, out of persons below the grade of the lowest of our managers, that is, below the grade of the deputies, I am sure it would not work well. I cannot think that sub-inspectors, below the grade of the lowest of our managers, can be of any service as inspectors, to give information to or instruct persons who ought to be much superior to them in knowledge and experience.

3849. Supposing those sub-inspectors were taken from a higher class, from the class of over-men or back over-men or under-viewers, would your objection cease in that case?—It would not. I will propose, with great deference, the system which, to the best of my ability, I think, would work best in bringing about a state of things to diminish accidents. I will now state the system I propose to adopt. In the first place, I have stated that I think the mines cannot be properly managed, or accidents prevented, unless you raise the class of managers to a higher state of intelligence. Now I think that requires the very serious consideration of the Legislature. I do not think at present there are opportunities requisite to acquire that sort of instruction which those persons want. There are no schools adapted to give mining instruction, not even in the districts of Northumberland and Durham, and still less in the other districts. I think that the requisite knowledge cannot be acquired without some general system of instruction proper for the mining managers; and I therefore, with great deference, submit to the Committee that their attention should be first of all directed to what system or course of instruction should be adopted or sanctioned or promoted by the Legislature, and how such a system could be carried out. I have paid very great attention to this for some years, and still more lately, with reference to the establishment of a mining school in Newcastle. I have come to the conclusion that all this cannot be brought about unless schools for the instruction of miners be established in different districts. I had last year pointed this out to the mining interests of Newcastle, and delivered a lecture upon that subject, which is of course too long to submit to you; but I feel quite certain that the time has arrived when some system of schools for mines must be established. I have likewise directed the attention of the Institution of Mining Engineers to this subject, which is stated in an inaugural address to that institution. I think that it would be of immense importance to the mining interests of this country, not only as regards the object which this Committee has in view, but generally to the commercial interests of the country, if schools of mines could be established in different districts of the kingdom. I will take that at Newcastle first, as bringing to your notice a practical mode of dealing with it. As president of the Institution of Mining Engineers, I put myself in communication with the University of Durham and with the managers of the Museum of Economic Geology in London; and some progress has been made towards the establishment of a school of mines in

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Newcastle patronised by the University of Durham, and connected with the Museum of Practical Geology in London.

3850. How is it to be supported?—It is proposed to support it by subscriptions from the coal-owners; we hope to get some assistance from the University of Durham and also from the Government, and the pupils will assist. The Museum of Practical Geology here in connexion with the Board of Trade and Industrial Arts Institution would also assist. They propose to assist us with models, and plans, and implements, apparatus, &c., requisite for establishing a school of mines. They would do that at an extremely low cost, and that is one part of the advantage which we shall gain by a connexion with the institutions here. Dr. Playfair also stated, that the Government would in all probability guarantee a certain sum annually towards the payment of the professors, on the assumption that subscriptions should be got up in the local places to a certain amount; that the Government would in the first instance guarantee the professors' salaries for three years, if the subscriptions did not amount to what was requisite. That would assist to a certain extent; and we hope that the University of Durham, who are very anxious to support an institution of this kind, will also assist us; and these, added to the subscriptions of the coal-owners and mining proprietors of the district, leave no doubt that in a short time we shall be able to establish a school of mines in Newcastle.

3851. Have you had communications with the coal-owners of the district upon that subject?—We have.

3852. Do you find any difficulty in inducing them to come forward in aid of the school?—At a meeting of the coal-owners they came to a resolution unanimously to support the Institution of Mining Engineers, and I have no doubt they would equally readily support a school of mines.

3853. Will they support it by a tax upon themselves, or by voluntary subscriptions?—By voluntary subscriptions. We hope, however, it may be self-supporting after it comes to be established; but in the meantime, the importance of such an institution is so great, that I trust it will also be supported by the Government, as well as the persons locally interested in the trade. On the Continent there are schools of mines of a similar nature; in Belgium and France; and certainly it is not very creditable to this country, possessing the most extensive mines in the world, that no such institution is in existence.

3854. But if the Government were to support schools of that kind, would it not be their duty to see that the owners of collieries only employed such men as had passed examinations in those schools?—It was proposed that, in connexion with this institution, there should be local schools, sort of preparatory schools for pupils entering the institution; that there should be a difference in the tuition in the institution; that there should be a class for the under viewers, and for those persons who are to be the practical operators in the mines, who, it was supposed, might acquire their education in 12 months in the institution after coming out of the local schools, and that those persons should have an opportunity of seeing the practical working of mines. Then the superior class of under viewers or viewers would go through a longer and superior course of education, and might receive honours which would entitle them to admission to the Government School of Mines in London on advantageous terms. It has been stated to us, that they would be at liberty to go there for 12 months without the payment of any fees; that the Government School of Mines would admit them into the institution merely on the payment of a very small sum sufficient for their board, and that then the course of education would be gratis; we presume it would be the superior class of pupils which would come to that school, where they would receive certificates of merit. Now connected with this, on the same principle, I think that schools of mines might be established in other districts of the country, also in connexion with the school of mines in London, and if advisable, they may be in connexion also with the school of mines in Newcastle. Persons from various districts entering the school of mines in Newcastle, would have an opportunity of seeing what is done in the mines there, and of course it would be advantageous to them to be enabled to do so. I have no doubt, therefore, that if some general system of instruction were deemed advisable, a course of education might be brought about which would raise the intelligence and knowledge of the class of managers I have pointed out, which would be extremely beneficial to the mining interest generally, and to the managers of mines; and would, in my opinion, much more than any system of inspection which is practicable, accomplish a diminution in the accidents in mines.

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I think the basis of the whole should be a general system of education to bring up such class of persons in sound practical and in such theoretical knowledge as is necessary for the management of mines, now becoming every day more dangerous.

3855. In order to give them practical knowledge, it would be necessary that they should visit the mines at the time they were seeking scientific knowledge, would it not?—It would.

3856. How would you accomplish that?—I think it would be necessary that they should be enabled to visit the mines occasionally, and I think, by arrangement, this is quite practicable; I think there could be no difficulty connected with the school of mines at Newcastle, in arranging that the pupils of that institution should acquire practical knowledge, at some period or other, while going through their studies at that institution; that they should, some period or other, be instructed in such practical knowledge of the mode in which the mines are conducted in the neighbourhood of Newcastle as would be extremely advantageous to them; and in the other districts they might have access to those mines which are conducted upon the same improved system of management; I think, connected with the whole of this system, it may be that certificates ought to be given by those schools of mines in the same manner as certificates of merit or efficiency are given to the pupils of the schools of mines on the continent. In my opinion, those certificates would be a very great inducement to pupils wishing to put themselves forward in acquiring information, and would certainly be a stepping-stone towards their employment in the mines as scientific and practical miners.

3857. Supposing this school were established, and were to accomplish all the objects you wish to attain, would you not make it compulsory upon the coal-owners to employ only such persons as had passed such necessary examinations as would be suitable to the situations they were intended to hold?—I think it might be advisable to make some such arrangement, though not compulsory; I find that the practical working of that system on the continent is, that pupils having obtained those certificates of efficiency, the mining interests, manufacturers and others are exceedingly anxious to get hold of them; that there is a demand for those pupils who have acquired that degree of proficiency, and I think that the coal-owners' own interest, in being able to obtain pupils of that superior knowledge, would induce them to employ them in preference without any compulsory means; if it was made a necessary part of the management of a colliery that persons of a particular grade of management should require a certificate, I do not see any objection to it, upon the same principle that the master of a vessel is required to have a certificate as to his proficiency in navigation.

3858. Do you not think it would be an improvement, inasmuch as although there are a number of coal-owners in this country, who, no doubt, would employ only scientific men, there are a number of small coal-owners, who, with an economic view, would endeavour to get a man at a small salary, who had not such an education as was necessary to enable him properly to conduct the mine?—I think, paying due attention to the variety of circumstances with which the mining interests of the country are surrounded, it might at some period hereafter be made compulsory that the managers of mines should have certificates of proficiency before they undertake the management of them.

3859. Mr. *Ingham.*] Might not this be the practical result, that as underwriters require, frequently, that the captain of the ship which they underwrite should be a certificated captain, so the lessors or mortgagees of mines, in order to ensure the security of that property in which they are interested, should make that stipulation?—The lessors of the mines have a specific class of persons to look after their interests.

3860. But might not they make it a stipulation, because any great injury to the property would damage their reversion?—No doubt; but I am not prepared to say that the coal-owners would object to any system compulsory upon them, that they should only employ in certain capacities persons having the requisite certificates of knowledge. Supposing all this could be carried out, I am quite sure it would be the means of raising up a class of managers very superior in knowledge to what now exists. Then I think the system of inspection should be based, not upon having anything to do with seeing that the under managers do their duty, but upon seeing that there is a proper system, or an efficient management adopted in the collieries, and that the system and rules are such as are adequate for the purpose.

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3861. *Chairman.*] In all the evidence given by the men who have been deputed to come here by the workmen, they have stated that they by no means wish to interfere with the coal-owner in any system of management he may think proper to adopt; all they would require would be that the inspectors should see that the mines were carried on in a proper manner to ensure the safety of the men's lives; to such an inspection as that, I presume, the coal-owners would have no objection?—Certainly not; provided it did not interfere with their responsibility. Now, looking at the present system of inspection, it is quite clear that the number of persons that are now employed is insufficient for the purpose, if they are to undertake all the duties which they appear to consider necessary in their office of inspectors.

3862. With reference to the present inspectors, have you found them interfere in any improper way with the collieries under your management?—No, I cannot say that I have; but they go upon a system of making suggestions, which are in fact orders. Those suggestions apply to the mode of distributing the air, and doing a great many things which, although sheltered under the name of suggestions, are really orders, and as such the responsibility is adopted by the inspectors, whether such orders are proper or not.

3863. But do they do so without consulting the head viewer or manager of the colliery?—Yes, I think they do; I think when the inspectors visit a colliery they look around them, and make up their minds whether everything is right or not, and then they go and make suggestions, sometimes in accordance with the views of the coal-owners, and sometimes not in accordance with them.

3864. Are the present inspectors, in your opinion, generally practically and scientifically capable of fulfilling the duties which are imposed upon them?—I think they are, generally; probably some of them would have been no worse with a little more practical knowledge, but I think, generally, they are a class of persons very capable of undertaking the duties of inspectors. I will state the system of inspection which some of the coal-owners I have consulted think would be most efficacious, supposing there were a proper staff of inspectors.

3865. Will you state what you would call a proper staff?—I think inspection ought to be conducted on a mode something like what the inspection of railways is; that it should become a separate department under the control of the Board of Trade.

3866. Do not you think it would be better under the management of the Board of Trade, or under the mines department, inasmuch as the Government School of Mines is under the Board of Trade, and the inspection of railways is under the Board of Trade; would you not think it more desirable to place it under that Board than under the Secretary of State for the Home Deparment?—I think the Board of Trade is the proper head for the purpose, because besides having the inspection of railways, they have under their management the school of mines; I think at present the system is very defective in that respect; each of the inspectors acts upon his own responsibility, without any efficient co-operation; and, again, if anything occurs between the inspector and the coal-owner, there is no head that the coal-owner can properly go to; I think if the management of the inspectors was under the Board of Trade as a system, and certainly the importance of the coal-mining interests is quite as great as the inspection of railways, and therefore demanding quite as much a separate department as the railway department; if it was in connexion with the Board of Trade, then, through the school of mines, the coal-owner might have some tribunal to which to apply in cases of dispute between the inspector and himself, which at present he has not; supposing a system of inspection should be established in this way, then I think it would not be necessary that the inspectors should be of a lower grade than they are at present. I think if we look at the system of inspection in Belgium, which has been very much brought out in inquiries of this kind, you will find that the system there is certainly not the employment of a lower grade than that of the present inspectors; the system there is very much what appears to me to be advisable here; the head of the system of inspection in Belgium is that of a director-general, who would be equivalent to the head of the Board of Trade here; he has under him an engineer-in-chief in each of the districts, who has under them engineers and sub-engineers; but it must be observed, that in Belgium the inspection extends to quarries, foundries, steam-engines, and are therefore more extensive than here.

3867. In Belgium those inspectors have not merely to inspect the working of the

the mines, but they are the agents of the Government, which itself works the mines?—They are; the mines are in the hands of Government, and besides having to look after the inspection of the mines, with reference to accidents, they act in the same way as our check viewers do here, which is another class of persons beyond those I have given you in the management of our mines.

3868. Those check viewers being agents for the lessors?—Those check viewers being agents for the lessors; and those are in addition to all the superintending viewers and persons I gave you before; they amount to a very considerable number, probably to 150. Now the state of things in Belgium is, that the inspectors undertake those duties as well as the duties of inspection, and therefore, the engineers and sub-engineers, under the engineer in chief, attend to the foundries, the steam engines, and all that, and only act occasionally in the inspection of mines. Then comes the assistant engineers; now those are the class of persons that are equivalent to our inspectors; those persons are employed solely in the mines, and are of a higher grade, or of an equal grade at least, with our present inspectors, certainly not below; they are, I should say, parallel with our resident viewers; they seem to me to be a class above that of the under viewers. Now the mines of Belgium being in the hands of the Government, the Government is interested in having those mines inspected in the most efficient manner, and they have a staff of inspectors or directors of superior knowledge, because those engineers in chief and the other engineers are men who have gone through the scientific colleges, and have very superior knowledge, and I think if the Government had been of opinion that a class of inspectors below that grade would be beneficial, they would have employed it there. They have certainly had more experience of inspection in Belgium than we have had, and I think it is a very strong case, that as they have not found it advantageous to employ persons of a lower grade than our inspectors here, it has not been deemed to be beneficial, and therefore, that is a proof to me of its not being advisable to resort to a lower grade of inspection here.

3869. Mr. *Ingham.*] Are you aware at all of what the feeling of the workmen and colliers is in Belgium as to the inspectors?—I am not.

3870. *Chairman.*] Are the Committee to understand you to recommend some such system of inspection as is carried on in Belgium?—I think there should be a staff of inspectors somewhat similar, to make the inspection efficient.

3871. Would you have a board in London, and under them inspectors, or would you have any intermediate person between the head of the Board of Trade in London and the inspectors themselves?—No; I think that if it were made a separate department, as the railway department of the Board of Trade, the head of which is the President of the Board of Trade, the inspectors without any intermediate class of persons would be sufficient, because the head of the Board of Trade, or his deputy, would, of course, consult with the professors of the School of Mines in case of any difficulty; I think it would not therefore be necessary to have any intermediate person between them.

3872. How many inspectors do you think would be necessary?—I cannot very well say how many until the system is determined upon.

3873. They should visit every mine in their districts at certain periods?—I think so.

3874. How often should they visit each mine?—Before going into that I should beg to point out to the Committee how I think the inspection should be carried out, supposing we had a staff of inspectors such as I have stated.

3875. What power would you give to those inspectors?—I think we should do as they have done in Belgium; that there should be a system of rules and regulations drawn out, which might be made a code of laws, and which should be the basis of a system of inspection. In Belgium, Mr. Mackworth in his evidence says, "There is a very excellent collection of rules for collieries, which are part of the laws of Belgium; each province had district regulations made by its own council, with the assistance of the engineers, and these were altered into a general law; before this law was adopted a council was formed, which was composed partly of colliery managers and partly of Government engineers, and having been agreed on, it was passed as a law." Now I think if a similar system were pursued here; if the colliery managers of the different districts could meet together, and meet the Government inspectors, and could agree amongst themselves upon a code of rules and regulations applicable to each of the different districts, (because they would vary according to the mines of the different districts); if they could agree upon a system of rules and regulations, which should not only go to the mode in

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which the mines are to be ventilated, but also into the system of management on which the different mines should be conducted, and if those were agreed upon and made a code of rules, then those should form the basis of what the inspectors ought to act upon. And I think every rule which would ensure safety in a mine, or prevent accidents, might be included in those rules and regulations, and I think the inspectors should not go beyond that.

3876. If you were to insert in those rules anything with reference to management, would not that be giving the inspectors a higher authority than you wish to confer upon them?—I do not mean to say that they should have anything to do with the management more than that they should see that the managers were persons competent to do what was requisite. Supposing, for instance, it were agreed upon by the coal-owners that the persons in the management of the mines should have a certain certificate of character, it would be necessary that the inspectors should see that that has been acquired by the person in the management of the mines. The manager of course must act at all times independent of the inspector, because he is to have the responsibility of the management of the mine; but whatever system the coal-owners may think right to adopt in the management of mines, should be incorporated into those rules, and then I think the inspector should see that those are carried out, and that that should be his duty. If it is necessary that in certain mines there should be a certain quantity of air, then the inspector should see that into those mines that quantity of air is introduced; but then I think that the mode of doing that should be left to the responsibility of the coal-owner.

3877. That would equally apply to the distribution of air?—And to the distribution also; I think those rules and regulations might be so made that the system of inspection would be more complete, and would less interfere with the responsibility of the management, and ensure greater efficiency than without any definite mode.

3878. Mr. *Ingham.*] Would not you have the inspector make it his business, not only to ascertain whether, at the time he was there, all those regulations had been complied with, but whether, during his absence, there had been any breach of those regulations?—I think not; practically he could not go into that, if he did it would require a number of inspectors far beyond what it is possible to keep up. I think you must throw the responsibility of the pits being always in the state in which they are when the inspector visits them, upon the coal-owner, and not upon the inspector, beyond looking after them at particular periods.

3879. From the evidence you have heard given by the workmen deputed by the different collieries, do you not find that they wish to have an increased number of sub-inspectors of a rather less elevated character, in order that they may with confidence communicate to them instances which have come to their own knowledge where those regulations have been violated?—I am well aware that the workmen are of that opinion; but I must beg to differ from them as to the utility of such a system of inspection. If we are to have a grade of persons not higher than the workmen themselves, to see that everything is kept right, I do not see why the workman himself, being at all times able to know whether he has the same quantity of air that he had when the inspector was there, should not himself give notice to the inspector when he finds anything wrong.

3880. The apprehension of the workmen is, that if they gave notice to the inspector, that would be more notorious than if they gave notice to the sub-inspector, who is more frequently among them, and that they might draw upon themselves the displeasure of their employers?—That is upon the assumption that the coal-owner is not desirous of carrying out what the inspector advises. Now I cannot think that such ought to be the conclusion; I think the coal-owner is the man above all others interested in carrying out what is proper.

3881. Does the workman come in immediate connexion with the coal-owner; is not the person who makes his situation comfortable, or the contrary, the overman, or deputy, or some officer in the mine, just a little above himself?—He generally comes to the under viewer; but then it is not necessary he should do so; it may be communicated to the inspector without the knowledge of the viewer; but I think if the system I propose were pursued, the coal-owners would not object. It may be made one of the rules to which the coal-owner should give his assent, and it should not be made a fault in the workman if he gave such information.

3882. I fully believe that the coal-owner would desire him to do so; but the question is, whether the workman himself would venture to act upon that impression,

sion, knowing he is immediately under the control of a man who possibly might feel himself censured by the information he gave?—I am quite aware that there is that sort of feeling; I think that arises from ignorance, and if you were to raise the intelligence of the persons conducting the mines, you would find a great deal of that feeling done away with; you find more of that sort of jealousy in mines managed by persons of inferior intelligence than you do in others.

3883. But as the gradual education and improvement of the working collier must be a matter of time, should you not think it desirable to consult what he himself felt would add to his own security, unless at the same time it should be found to be detrimental to the interest of the coal-owners?—I am myself persuaded that it is not the best system, and that it would not add to his security; I am quite sure, from my experience, though I have every desire to pay due deference to what the workmen wish, that it would lead to confusion of management, and not accomplish what they desire. I should say, that in following out the system I propose, it would be quite necessary that the inspectors should have diplomas of competency as well as the managers of mines.

3884. *Chairman.*] Have you seen the rules proposed by the inspectors who have been examined?—I have.

3885. Do you approve of those rules?—I think they are very much short of what is required in this country.

3886. They wish to ask additional powers; do you think those powers which they wish would be onerous to the coal-owners?—I think to several of them there is not the least objection; generally, I should say, they are not objectionable; but some are, and I think they do not go far enough in some respects to ensure the prevention of accidents. The code of rules that I propose would go to a very much greater extent than those propositions, and then, after the rules are once laid down, I would not make it discretionary in the inspector to interfere beyond them; if he finds the rules insufficient let them be increased by co-operation between the coal-owner and the inspector, with an appeal to the Board of Trade, to the institution in London, or to some practical tribunal.

3887. Have you drawn out a code of rules?—No, I have not. You will find in the proceedings in 1845, in Professor Phillips' report and in the proceedings of last year, rules at the different collieries which are very complete. I have no further rules to suggest, but those refer to the working of mines as well as to the ventilation of them; they are carried beyond what are necessary for the powers of the inspectors, and therefore they are not strictly applicable to them.

3888. But you would suggest that all those rules laid down which do not actually apply to the working of the mines should be made applicable to the inspectors?—Just so. I think the viewers of the different districts should meet together. I know no other mode of so effectually obtaining a class of rules or a code of laws, as by such a principle of dealing with them.

3889. Then you suggest that a code of rules should be determined upon by consultation between the inspectors and the principal viewers and coal-owners of the whole country, and that those rules should be made the law of the land?—I do.

3890. Supposing those rules were made the law of the land, you would suggest that there should be contained in those rules no interference in the least in the management of the mines?—Certainly there should not; I should wish them to be as efficient and complete as possible for a system of inspection that would best attain the objects in view, and then if at any time afterwards they were found defective, then I think additional rules or bye-laws might be adopted in concurrence between the coal-owners and the inspectors, which might be added to them.

3891. But suppose the coal-owners and inspectors could not agree, would you give the Board of Trade, or the head authority in London, power to make any rules which he thought fit?—I think so; calling into his council proper practical persons for assisting him in doing so.

3892. Mr. *Ingham.*] You said that the check viewers would form a body of 150 additional men to the number of officers you named?—I think they would.

3893. No doubt the system of check viewing would assist very much the inspection of particular mines, and multiply the instances of inspecting visits?—Yes.

3894. But, in point of fact, it would not make any addition to the body of

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viewers; are not the check viewers the same body of individuals whom you have already mentioned as head viewers, superintending viewers, or resident viewers?—They are included within the number of persons I have named.

3895. They form part of the number you have given?—Yes.

3896. Can you give any idea of the number of workmen employed in the collieries, so that we may know what the proportion of officers is to the actual workmen?—I think there are between 20,000 and 30,000.

3897. In that same district of Northumberland and Durham?—In the same district; I think somewhere thereabouts; I do not recollect whether the whole numbers are correct.

3898. But you are only speaking of that one district?—I mean the entire mines in the counties of Durham and Northumberland yielding about 10,000,000 tons of coals per year.

3899. *Chairman.*] You stated just now that you did not consider the number of inspectors sufficient; will you state to the Committee what number of inspectors you think would be sufficient?—I could not very well state that until the system of inspection is determined upon; I think, if the system I propose is determined upon, it will be very easy to fix upon the requisite number of inspectors.

3900. Have you anything else to say upon this branch of the subject?—Nothing more occurs to me at present.

3901. As to coroners' inquests, do you think the present system of coroners' inquests is a good one?—I do not see what other mode can be adopted better than the present system. I think it would add very much to the efficiency of the system of inspection if the proceedings at coroners' inquests could be recorded in some way or other, and also the proceedings of the inspectors, and the system that I propose would accomplish that object, because, in the office in London all those could be deposited, and it would aid very much in the prevention of accidents to know how the accidents do occur; therefore I think it ought to be made compulsory as to coroners' inquests, that an official account of the proceedings should be recorded.

3902. Now the coroner has only power to return a verdict of accidental death or manslaughter; can you suggest any intermediate course?—No, I cannot.

3903. With regard to a system of schools for children, in your opinion is it incumbent upon the owners of collieries to provide schools for the education of their workmen's children?—It is not incumbent, although it is a practice which is almost universal, and certainly a practice which is very necessary. I believe Mr. Tremenheere is now reporting to Government, with a view of making it compulsory that boys within a certain age should attend at schools so many hours a week.

3904. Some of the witnesses have stated that boys should not be allowed to go into collieries until they are 12 years of age, instead of 10; would you approve of such a regulation?—I think not; I think it would be a great hardship upon some of the parents to do so; if an arrangement could be made by which the children could go to school a certain number hours a week, I think that would accomplish their education, without keeping them out of the mine.

3905. Mr. *H. A. Bruce.*] Up to what age does Mr. Tremenheere propose to keep them at school?—I believe it is up to 13; and in that case, supposing that to be done, it certainly would be necessary to have schools in each colliery district.

3906. *Chairman.*] Some of the persons deputed by the colliers have told the Committee that the colliers themselves would not have an objection to a rate being levied upon them, to be stopped out of their earnings, for the support of schools connected with the collieries in which they work, provided they had some voice in the selection of the schoolmaster, and in the management of the schools; do you approve of that suggestion?—I do not. When the late Lord Wharncliffe was alive, at his suggestion I adopted that system at Killingworth, but I found it worked very badly.

3907. Mr. *H. A. Bruce.*] Did it work badly in consequence of difference between the men and the masters?—The workmen differed amongst themselves about it, and it was obliged to be abandoned.

3908. With reference to the first part of the question, do you think that generally the men would be inclined to tax themselves or to allow a certain portion of their wages to be deducted, in order to support the school?—Yes; I never found any difficulty with the men in subscribing towards the school; but I think, if a system making it compulsory upon the men that their children should go so many days a week to school, was carried out, it would accomplish the object.

3909. Are

3909. Are they generally negligent upon that point in the north of England?—No, I think not; I think there is a very good disposition in the workmen to have their children educated. We have schools attached to each colliery, and we find them very well attended.

3910. *Chairman.*] How are those schools supported?—Generally by subscription from the coal-owners and by a small payment from the men for their children.

3911. Mr. *H. A. Bruce.*] Who practically superintends the schools?—The coal-owners, and sometimes the clergymen of the district; it depends upon what educational system the schools are on, under what institution, or connected with what sect.

3912. *Chairman.*] Is it your opinion that the men should provide a fund by contribution, for relief in cases of accident, and also for the assistance of the widows and orphans of those who meet their deaths by accidents in the mines?—The coal-owners in the districts of Northumberland and Durham pay a certain amount a week to persons maimed in the pits, and they generally make a subscription to the widows in all cases of death; the men very generally subscribe to the surgeon for cases of sickness, there being in addition at every colliery a surgeon paid by the coal-owner to attend to them in case of accident.

3913. Then in Northumberland the men do not contribute so much a week of their earnings to the surgeon?—Except in cases of sickness.

3914. In South Wales the men pay a certain proportion per month of their earnings all the year towards the surgeon when they are well; of course when they are ill they do not earn anything, and the surgeon is obliged to attend them and their families as long as they may require his assistance?—That is so in Northumberland and Durham; the coal-owner in addition paying the surgeon in case of accident.

3915. Is it your opinion that the colliers themselves should provide a fund for relief, in case of accident, and should contribute towards a fund for the support of the widows and orphans?—I think it would be a very good thing for them if they did; it would be beneficial for them, but I do not find that that is the case; they often contribute to a fund for provision in cases of being off work in consequence of being lame, or in cases of sickness.

3916. Mr. *H. A. Bruce.*] Do you think they would object to paying to a sort of insurance fund?—I think they would; I think they would object to anything compulsory for such a purpose.

3917. *Chairman.*] Do you think the class of colliers is improving, in the north of England, in education?—They certainly are a more intelligent class than they were when I first knew the trade; and I am firmly convinced that their improvement is beneficial to the coal-owner as well as to the workmen themselves, and it is with that view that I am so strongly inclined to promote a general system of education.

3918. Mr. *H. A. Bruce.*] Is the mining population of the north of England tolerably stationary, or is it largely recruited from the agricultural districts?—They are generally stationary in the coal mines and iron mines; there has not been very much emigration from the counties of Northumberlnd and Durham until recently.

3919. But has there been immigration; is the population fed and sustained principally from the agricultural districts?—I think not; they keep very much within themselves.

3920. Mr. *Ingham.*] You mentioned that you think the workmen are gradually becoming better educated?—I think so.

3921. Is it not the case that, in the unfortunate strikes that have sometimes occurred, each succeeding strike has exhibited fewer instances of violence and outrage?—I think so; I think, as the intelligence of the pitmen is increased, it makes them better workmen, and less inclined to violence; that has always been my experience in all those collieries; where they are best educated they are the least mischievous.

3922. Mr. *H. A. Bruce.*] Is it the fact that the mining population of England, both in Northumberland and Durham in the north, and Cornwall in the south, are the most innocent population in Great Britain; that the smallest per-centage of crime is found to exist in the whole mining population?—That is certainly my belief; I consider the class of coal-miners in Northumberland and Durham is an exceedingly peaceable and well-inclined class.

3923–4. Whereas the population attached to iron-works are, next to the metro-

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politan population, the most criminal?—That, I think, will depend very much upon how they are situated; the mining population of Northumberland and Durham is very much under the eye of the masters, and unconnected with the towns; and in that, I think, it is that they have an advantage, by being looked after and their comfort promoted by their masters, and you find them a very superior class of men the further they are removed from the towns.

3925. *Chairman.*] Is there anything else you wish to state to the Committee?—No, nothing further occurs to my mind at present.

Jovis, 21° die Julii, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Child.
Mr. Ingham.	Mr. Cobbett.
Mr. Baird.	Mr. Locke.
Mr. Cayley.	

EDWARD J. HUTCHINS, Esq. IN THE CHAIR.

J. Kenyon Blackwell, Esq., called in; and Examined.

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3926. *Chairman.*] YOU are a Mining Engineer?—Yes; I have been engaged during the greater part of my life as a managing partner in iron works, which has entailed, of necessity, the direction of mines.

3927. Mr. *Baird.*] Where?—In South Staffordshire and South Wales.

3928. *Chairman.*] In 1849, were you desired by the Government to report upon the state of the mining districts, with a view to the prevention of accidents?—Yes.

3929. You made a report, which is printed, and is dated 25th March 1850?—Yes.

3930. Were the principal recommendations of that report, that in all fiery mines the Davy lamp should be compulsorily used, and that mining schools should be established?—The principles upon which ventilation ought to be conducted were explained; a more extended use of the Davy lamp was recommended; and the education of the mining population.

3931. To what district did you pay particular attention?—To the state of mining throughout England. My commission extended directly to the southern counties; but I accompanied my colleague, Professor Phillips, of York, in some of his visits to the north of England, with which I was previously well acquainted, from my general attention to the subject.

3932. Have you had extensive experience in almost every district in England?—I have.

3933. Have you also had experience in Scotland?—No; I have some general knowledge with regard to the state of the Scotch mines.

3934. Do you consider that any particular law could be made applicable generally to all the districts of this country, for the prevention of accidents in coal mines?—I do not think that any general law could be framed which would have that tendency, beyond one or two special enactments. I think that a few enactments might be desirable.

3935. Have you come to that conclusion in consequence of the different characters of the coal mines in different districts?—I have.

3936. Will you describe the different characters of some of the coal mines, which have induced you to come to the conclusion that no such law would be available?—The modes of working coal vary greatly, from the differences in character of the coal seams themselves, and of the coal fields in which they occur. It is difficult to make any comparison between the immense collieries of the north of England, where the regularity of the strata and the depth of the mines occasion the working of one or two square miles of coal from a single winning, and collieries in such districts as South Staffordshire, where the faulty nature of the ground, and the shallowness of the seams worked, cause them to be limited on an average to five or ten acres. I am putting the two extreme cases in this instance. The mines are on the largest scale in the north of England, and on the smallest scale in South Staffordshire.

3937. Looking

3937. Looking at these differences, would you be disposed to recommend this Committee to report to The House any particular method of ventilation?—No; I think that is a question which must be left entirely in the hands of the mining engineer, who has the direction of the mine itself. I do not think it is possible to lay down any general mode of ventilation, the differences of the mines being in themselves so great, and their exigencies so various.

3938. In the districts in the north of England, and in other parts where the mine is deep, and large quantities of coal are worked at one winning, is it more necessary to have greater ventilating power than in such a place as South Staffordshire, where the mines are easily worked, and very little coal is got from one pit?—Yes.

3939. Are you aware of instances in which you could recommend pits to be worked upon what is called natural ventilation; that is, without any artificial ventilation whatever?—I think, that with the exception of during the summer period in South Staffordshire, where there are a pair of pits in almost every field, natural ventilation is quite sufficient to supply the requirements of the mines, if proper air-ways are opened to allow the air to pass from one pit to the other. In the summer time, perhaps, a small moveable lamp may be requisite.

3940. In case of storms, however small the ventilation may be, might it not happen that the barometer might be so affected, that the ordinary up-cast shaft would be rendered a down-cast shaft, even in winter, or the air in the two shafts rendered immoveable, and the ventilation thereby stopped?—That is very rarely the case, I think, where proper air-ways are opened, even under such circumstances; because the heat of the mine, resulting from the natural elevation in temperature of the strata, and the heat communicated by the lights, the men, and horses in the pit, nearly always elevate the temperature of the air to a sufficient degree to maintain the ventilation.

3941. Mr. *Baird.*] In your experience, did you ever see the air in the up-cast and down-cast shaft motionless?—I cannot say, that under any circumstances in which I was satisfied that proper air-ways had been opened between the two pits, I have ever seen the air motionless; but if the temperature in the mine were below that of the atmosphere, it might be so.

3942. *Chairman.*] In the district of Northumberland, and other districts where the pits are deep, and the quantity of coal to be worked out of each pit is large, your opinion is, that some artificial ventilation is absolutely necessary?—I think it is absolutely necessary.

3943. At the same time, you would not prescribe any particular mode of ventilation, but would rather leave that to the coal-owners themselves, desiring that the inspectors should simply see that a sufficient quantity of air was carried down into the pit and properly distributed?—That is the course which I should recommend.

3944. Of course there is a great variation in the quantity of air required; and that would depend, no doubt, upon the extent of working and the number of men in the pit; can you give the Committee any idea of what, in your opinion, is the relative quantity of air to the size of the working in operation, and the number of men who are employed?—I consider the number of men who are employed to be in some degree a measure of the extent of the surface of coal exposed; and therefore I think that may fairly be taken as the standard, to which some definite scale may be affixed.

3945. Can you give the Committee any idea of the quantity of air that is required for each mine, according to the standard you now suggest?—I think it would be difficult to state a standard which should extend to all the mines in this country. I think I stated, in my report to Sir George Grey, that in many of the most fiery mines as much as 500 cubic feet per minute is given.

3946. Is that quantity found to be sufficient in those fiery mines?—I think it is, under ordinary circumstances of a regular discharge of gas; but even that quantity is not sufficient under extraordinary circumstances; that quantity, however, far exceeds what is requisite in a large number of the mines of this country; and I should say that it is from twice to four times the amount which is necessary.

3947. When you speak of large quantities of gas, you mean in cases of blowers, or accumulations of gas which suddenly escape?—I allude to the accumulations of gas which suddenly escape from the coal itself, or from the strata above and below the coal; and I also allude to the quantities which may overflow out of large goaves, when the barometer falls suddenly.

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3948. Is it your opinion, that natural ventilation may be allowed, if great care is taken to keep the air-ways sufficiently capacious to pass the air without too much friction through the workings, in certain cases?—Perhaps you will allow me to make a qualification of my last answer, before I answer that question; that is, that some coal seams are liable to spontaneous combustion, and it is necessary in such seams, where they are not completely cleared out of the ground, that the quantities of air circulating in them should be restricted; even the lowest quantity which I have mentioned would be inconvenient, and productive of damage in some of the Thick coal workings, for instance, in South Staffordshire, which are worked by the old system of stall-working, and not worked by long work. Where the seam is worked by the old system, a large quantity of slack is left underground; large ribs and pillars are left which are crushed; and the whole of the abandoned workings are liable to burst into flame if they are not sufficiently excluded from the air.

3949. Mr. *Ingham.*] What is the quality of that coal?—It is a very pure coal.

3950. *Chairman.*] Is the spontaneous combustion caused by the iron pyrites?—That is a question which has not been fully determined; it has generally been supposed that it was caused by the iron pyrites in the coal; but this is very pure coal; still sulphuret of iron may be disseminated in the bands of shale which separate the beds without being visible to the eye.

3951. Or mixing with the coal?—Yes.

3952. How can the working of coal of such a quality be carried on with due regard to the health of the men; because, unless sufficient air is carried through the working, which quantity would make the coal ignite, the men would not breathe a healthy atmosphere?—The atmosphere in such pits is commonly injurious to health; and such a state of ventilation might be obviated by a better mode of working that seam.

3953. You are alluding now to long work?—I am alluding to the ordinary mode of working the Thick coal seam in South Staffordshire, as compared with working that seam by long work.

3954. Is that mode practised in South Staffordshire principally?—That seam is worked by long work in Staffordshire, in some collieries; for instance, in the very extensive collieries of the late Mr. James Foster, at Shut End, in the collieries of Mr. Gibbons, adjoining, and now, I believe, by the British Iron Company at Corngreaves.

3955. In your opinion, is that system better for ventilation?—It enables a much more perfect ventilation to be obtained, because the seam is entirely worked out and taken out of the mine, and no spontaneous combustion can occur.

3956. Although the seam is taken entirely out of the mine, are not great quantities of refuse coal and rubbish left to fill up the vacant space?—The roof fills up the vacant space; the whole of the coal and slack is taken out of the mine.

3957. Do you mean that the whole of the coal is taken out, and that nothing is left in, and that the roof is allowed to fall and to touch the bottom?—That is what I mean; but it is done by working the coal by successive operations; it is not all done at once. There has been an opinion in South Staffordshire that that mode of working coal caused the seam to be brought out of the mine in smaller lumps, and that has been the source of the objection to it; but, on the other hand, the quantity of coal obtained from the seam is so much greater, that I do not think it is a sufficient objection.

3958. In the great coal fields of Northumberland and Durham, the system of long work is not adopted?—It is rarely practised; I think it is adopted in some of the mines.

3959. Do you know the reason why it is not practised?—The mode of working in this district is almost exclusively on the pillar and stall system, the coals being found too tender and jointy to allow them to be wrought generally by long work.

3960. Has it been the practice to reduce very large tracts of this coal to a state of pillar or waste before working them out?—It has been the practice to reduce very large tracts of coal in this district to the state of pillar or waste, before finally working out these pillars. These wastes sometimes extending over one or two square miles in the larger collieries, require ventilation, as well as those parts of the workings progressing in the whole coal.

3961. Do those great wastes weaken or strengthen the ventilation?—They admit of considerable leakage by the numerous passages which are open in every direction

direction through these wastes. Although they permit the circulation of very large bodies of air, by its division into separate currents, yet the imperfect nature of the stoppings employed to close the openings, everywhere entering the wastes from the main roads, in order to force the ingoing air-currents up to the more distant workings, frequently allows much of the air to leak back to the up-cast shaft, and leaves the ventilation weak in those distant workings in which the largest supply is required.

3962. Are these stoppings in general made sufficiently strong for cases of explosion?—They are not. The collieries are usually divided into a number of separate districts, which would produce a very important result if the stability of these stoppings were properly attended to.

3963. The circulation being destroyed generally in explosions by the stoppings being blown away?—The circulation is generally destroyed, in explosions, by all the stoppings and doors being blown away.

3964. Can you describe any mode of reducing these wastes, so as not to leave such great deposits of gaseous gunpowder in the mine?—It is now, in some cases, the practice to diminish the extent of coal left in the state of waste, by working out the pillars closely following the workings on the whole coal. This change tends to shorten the air-currents, and to reduce the quantity of air required for ventilation.

3965. In your opinion, should such a change become general?—It appears desirable that this change should become general; that the division of the mine into districts should be so fortified as to effect a secure separation between the ingoing and outcoming air-currents, and that those air-currents should be so directed as to prevent the fire-damp yielded by the goaves from entering the working districts. I have endeavoured to show the mode in which the ventilation might be so arranged in a plan which is annexed to my Report to Sir George Grey in 1850. With these precautions, accompanied by good ventilation, explosions would probably not occur, or when occurring, would not be attended by a large loss of life.

3966. It has been stated by Mr. Wood, that in the best regulated and best managed collieries of Northumberland and Durham the use of doors is altogether abolished; have you seen collieries worked on that system?—I have seen that system most completely carried out in those collieries of Mr. Wood's which I have visited.

3967. In your opinion, has the number of explosions diminished in Northumberland and Durham?—In my opinion it has, when compared with the extent of coal which is worked.

3968. Do you believe that diminution has arisen principally from better ventilation?—I think so. The greatest attention has been paid of late years by the mining engineers of that district to the subject, and their knowledge and skill as miners, as well as their general attainments, are very great.

3969. Besides the diminution in the number of explosions, upon the occurrence of an explosion in that district is there now a less sacrifice of human life than formerly?—I do not think that any explosions have taken place in collieries which have been managed so as to allow doors to be done away with. I do not think we have had any means of testing that, except theoretically, in that district at present. Explosions have not occurred in such collieries, probably from the superior skill which has been displayed in their management.

3970. Mr. *Ingham.*] Do you know how that was in Hebburn Colliery?—I have not seen a plan of that colliery.

3971. *Chairman.*] Is it not obvious, that if an explosion took place in a colliery that had no doors, or scarcely any doors, there would be a much greater chance of escape for the men from the after-damp, provided the explosion took place from an escape of gas?—I am fully convinced that the doing away with doors in collieries would be attended with a great saving of life in cases of explosions; and I have strongly recommended it on every occasion that I have had to report upon an accident, and in my general report of 1850.

3972. Have improvements taken place in the ventilation of collieries since you sent your Report in 1850 to the Home Office?—The period is so short, that I think it is scarcely possible to form a correct opinion on that subject; but I know that at the present time the greatest interest is felt by the mining engineers of the north of England on the subject of accidents, and that they are sparing no labour, and are entering into most extensive investigations, for the purpose of determining their causes, and of preventing them if they can.

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3973. In your opinion, is the system in the north of England better and more calculated to prevent accidents than any other?—I cannot compare the system of the north of England with that of other districts, because the nature of the mines is so different. I think, upon the whole, it is better. I should say decidedly that the management is more skilful and more scientific in that district.

3974. Will you describe the coal fields and collieries of Lancashire, in order that the Committee may form an idea of the difference?—In Lancashire the coal measures are more intersected by faults than in the north of England. The inclination of the measures is greater. They frequently lie at very steep angles. The depth and cost of the winnings is ordinarily much less, and also, from these circumstances, the extent of ground worked from each winning. From the steepness of the measures, the main roads are usually those driven on the level course of the seam from the shaft, which produces a concentration of the working of one main road or rolley way; but in the more extensive collieries, a series of level roads are driven at suitable distances on the rise and to the dip, which are connected together by inclines at right angles to the level course. These are worked by machinery, on account of their steep inclination.

3975. Will you describe the mode of working?—The coal is usually partially worked as the level roads are driven from the shafts to the boundary on each side; the district between the shafts and the workings, which are pushed forward in the whole coal as the levels are driven, being left behind in the state of pillar or waste, to be worked out in returning. The consequence of that system is, that the air circulating in these mines is commonly restricted to a single current, or occasionally ,where there are workings on both sides of the shafts, the down-cast air is split into two currents. The ingoing air is, in most cases, only divided from the outgoing current, returning through the waste in a contrary direction towards the up-cast shaft from the extreme workings, by imperfect and insecure stoppings.

3976. Is that what is called coursing the air?—No; it is not, properly speaking, coursing the air; the system is generally what may be called ventilation by sheathing; that is, the old system of carrying one current all round the works, leaving the interior waste unventilated; but the air might be coursed on that system; the system of coursing the air is carrying one current throughout the mine, and carrying it into every part.

3977. Do these insecure stoppages of which you have spoken weaken the ventilation?—They generally allow much leakage to take place; the current in the extreme workings is therefore weak, being less than the total quantity introduced.

3978. Is that occasioned by the leakage in the stoppings?—It is occasioned in part by the leakage in the stoppings, and in part by the inadequate sectional area of the air-ways.

3979. Is not proper attention paid in Lancashire to keeping the air-ways of sufficient size?—The air-ways, by which the outcoming air has to find its way in returning through the wastes to the up-cast shaft are usually very small, and partly filled with rubbish, the falls not being cleared out; it is thus impossible for any large body of air to circulate, the sectional area of these passages being in no way proportional with that of the shafts. The air circulating being, moreover, confined to a single current, a large volume, even if the air-ways were of a size to permit its circulation, would be very inconvenient to the workmen, when the air is carried all round the works in one column, in that manner.

3980. Is that because the air would travel too rapidly, or that it would become impregnated with deleterious gases?—From both causes; but it is felt by the men, from the circumstance of its travelling too rapidly.

3981. Might not the air thus carried become explosive?—It frequently does become explosive; it is rarely the case that proper air-ways have been provided to carry off the fire-damp, which is discharged from the rise end of the goaves so formed; and the air current, after it has swept along the edge of these goaves, is frequently explosive, while its course brings it on the lights of the men.

3982. Supposing that an explosion should take place with this system, would not these imperfect separations be blown out, and the ventilation cease?—That is commonly the result when an explosion happens in such a colliery; the ventilation cannot be re-established by any means until the stoppings are restored in a temporary manner.

3983. Then the Committee are to understand that, in your opinion, in the Lancashire district, sufficient attention is not paid to what is called splitting the air?—In my opinion, in the Lancashire districts, sufficient attention is not paid to dividing

dividing the mine into districts, and spreading the working over a sufficient area, and splitting the air.

3984. You have not yourself had any experience in Scotland?—No.

3985. Was there not an explosion, a short time ago, at a place called Nitshill?—There was; and in that case the ventilation was confined to a single air current, which passed from one district to another, around large unventilated wastes, which was proved by the result in that case to be extremely dangerous.

3986. Did you examine that mine?—I have not examined the mine, but it is evidently the condition of the mine, from the plan which has been published in the report of the Government inspector.

3987. Mr. *Cayley*.] Do you know when the Government inspector visited that mine?—I do not know anything of the circumstances attending that explosion, except what is stated by the Government inspector in his report.

3988. You do not know whether the Government inspector was there before the accident or after the accident?—I cannot tell at the present moment, without referring to his report, but I presume that the plan which is given in his report is the plan which was produced at the judicial inquiry which took place on the subject, and I presume that we may consider it to be an authenticated plan.

3989. Mr. *Child*.] You are aware that Mr. Dunn gave an opinion after the explosion that the ventilation in the mine was very good?—I am aware that he gave that opinion, but I must on mature consideration beg to dissent from it; I consider that no pit could be well ventilated which was ventilated upon the system described by Mr. Dunn in his report, and shown by the plan which is annexed to that report.

3990. Mr. *Cayley*.] Is it not the fact, that when an explosion has taken place there must naturally be a great increase of ventilation in the down-cast pit?—I conceive there could not have been a great increase in that mine immediately after the explosion, because all the stoppings were evidently blown out, and no possible circulation could take place except from shaft to shaft. If the heat caused by the explosion remained in the mine, it would increase the ventilation.

3991. The effect of the expansion of the heat would be to produce a rarefaction of the air in the up-cast shaft, and if there was a direct gallery between the down-cast shaft and the up-cast shaft, the effect would be that the heat caused by the expansion would produce an increase of ventilation?—I think it would be only temporary.

3992. Supposing that Mr. Dunn visited the mine during that temporary accession of ventilation, might it not be an erroneous conclusion if he stated that the ventilation was sufficient?—I do not think it is possible that the accession of temperature caused by the explosion could have lasted long enough to have continued till he visited it; and, moreover, he could not visit it until some considerable period had elapsed after the explosion, because the mine must have been inaccessible until the stoppings could be restored.

3993. Are you aware, practically, whether there was any artificial ventilation or not in the Nitshill Colliery three months previously to the explosion taking place?—I believe it is stated in Mr. Dunn's report that there was no artificial ventilation.

3994. *Chairman*.] Are you personally acquainted with the coal field of South Wales?—Yes.

3995. For a long period of years, was the coal field of South Wales worked near the crop?—It was.

3996. And now the mines are getting deeper, are the deep mines found to be very fiery?—The deep mines in the valleys, where the basset edges of the strata are not exposed, are very fiery.

3997. Is the principal mode of working which has been adopted there, long-work or pillar and stall work?—The mode of working has been by pillar and stall almost exclusively; the stronger defined cleavage in the seams not allowing long work to be generally adopted.

3998. Are any of these collieries as large as the collieries in Northumberland and Durham?—The extent of none of these collieries is at present so large as the collieries of Northumberland and Durham.

3999. Is it considerable?—It is considerable; and as the winnings extend to the deep, they must, from the nature of the surface, become of great magnitude.

4000. From the inclination of the strata, do you consider that the collieries of South Wales are difficult or easy to ventilate?—The inclination of the strata has caused

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caused extensive workings to be crowded frequently on one level course, and that results in a number of lateral openings, forming passages for the escape of the ingoing air into the return air currents, and creates a difficulty in ventilation.

4001. Is proper attention paid, in your opinion, in South Wales to carrying in the air-ways, and to driving proper air-ways in advance in the solid coal?—I do not think that sufficient attempts are made there to form a complete system of air-ways before working the coal; that systematic arrangement of the workings which is necessary, and ultimately most economical in extensive and fiery mines, has been neglected; the ordinary practice has been to work the coal in stalls, as the levels progress from the shafts, conducting the outcoming currents of air returning from the face of the levels, and from the workings in the whole coal near their face, back to the up-cast shaft through the abandoned stalls; proper air-ways ought to be driven out in the solid coal in advance of the workings, parallel to each level, at a suitable distance to its rise, when not provided by the existence of previously exhausted levels in this position; these air-ways ought to be connected with the levels by cross-headings driven through from one to the other before the working of the coal is commenced; the want of such a system of air-ways compels all the air entering each level to be confined to a single current in the workings, and further restricts the quantity circulating in that current by the contracted passages through which it must pass; in that district the stalls are carried too wide, and the pillars between them are left greatly too thin; the roof thereof breaks down in the stalls before the pillars that are necessarily left to support these imperfect air-ways can be extracted; the pillars are thus crushed and lost, causing a great waste of mineral, which might be avoided if the general plan of the workings and of the ventilation were better devised.

4002. Does that system, in addition to the great quantity of coal that is left, crushing the air-ways, tend to weaken the ventilation and render the pit dangerous?—It does; and the system of ventilation is generally insecure, by the want of proper separation between the ingoing and outcoming currents.

4003. In the districts of Lancashire and South Wales, do you consider that the class of underlookers are equal to those in Northumberland?—They are not, if they are taken as a class. In many of the large iron works, unquestionably, men of considerable skill and knowledge of their profession are employed; but taking the collieries throughout that country generally, the managers are generally very deficient in their attainments.

4004. Is the same system adopted in Derbyshire and Yorkshire as is adopted in South Wales. The system is not similar in those districts; coal is worked generally by modified forms of long work in Yorkshire and Derbyshire, and the ventilation is often in a very dangerous state. I am acquainted with a good many of the Yorkshire mines in that district where great explosions have occurred, and I know that the ventilation is very imperfect.

4005. What class of men are the underlookers and viewers in that district?—Taken as a class, they are not generally so highly educated as they are in the north of England, although there are, unquestionably, viewers in that district of great attainments.

4006. In South Staffordshire, have the explosions been numerous and fatal?—They have been very numerous, compared with the very small quantity of fire-damp which is evolved in the mines there.

4007. Have they been confined usually to any particular district?—They have been confined almost exclusively to the thick coal.

4008. To what cause do you attribute those accidents?—Generally to a total absence of ventilation in the mines in which they have occurred.

4009. Mr. *Child.*] Have they been most frequent in large collieries or in small collieries, in South Staffordshire?—I think that the explosions in South Staffordshire have occurred in collieries which I should call collieries of the second class, and not of the first class.

4010. *Chairman.*] Did they arise at all from the objection to introduce too much air into the workings, in consequence of the tendency to spontaneous combustion?—Partly, and partly from the want of proper air-ways, which causes the current to be almost stagnant, if not quite stagnant, at many periods of the year.

4011. Mr. *Child.*] Were the collieries in South Staffordshire, in which the accidents occurred, without any means of artificial ventilation?—They generally only use occasionally what is called a lamp or fire-pan for that purpose; but I must be

be permitted to observe, that they have commonly occurred from a want of vigilance on the part of the man who is employed to examine the colliery in the morning; men have gone straight down into the pit, where gas has been found, without any examination with the lamp.

4012. Do you know anything of the collieries in North Staffordshire?—I have visited the greater part of them.

4013. How did you find those collieries ventilated?—The ventilation there is ordinarily imperfect.

4014. *Chairman.*] Do you think that explosions might be easily avoided in this district?—The country is very faulty, and the faulty nature of the ground interposes difficulties to ventilation. One of the worst ventilated collieries which I ever saw was in North Staffordshire, in which an explosion has subsequently occurred. It was an extremely faulty colliery.

4015. Mr. *Child.*] Where was that?—At Ubberley.

4016. That is one of the worst ventilated collieries you ever saw?—It was when I was in it.

4017. When did you see it?—In the year 1850.

4018. How soon after you saw it did the explosion take place?—I think from one to two years.

4019. Do you know the circumstances under which that explosion took place?—I know that when I was in the mine, the air was nearly explosive in almost every part of it.

4020. Were any artificial means of ventilating the mine employed?—Yes; there was a furnace there.

4021. To what cause was the deficiency of ventilation attributable?—It was confined to one current, and carried through small air-ways, in which there was not sufficient sectional area; it was carried from one seam to another; and it would have been explosive throughout the mine, if it had not been for the large quantity of carbonic acid which was in the current, as well as the hydrogen gas.

4022. *Chairman.*] In a thick seam, is it the practice to carry the air-ways at the top of the seam?—It is not invariably the case; it is only occasionally so; in point of fact, in some parts the thick seam in South Staffordshire yields so little fire-damp that it is not necessary. There are pits in that country where fire-damp is never seen, from their being so near the surface, and surrounded by old workings.

4023. Mr. *Child.*] Is there much fire-damp evolved from the mines in North Staffordshire, generally speaking?—Some of them are rather fiery.

4024. Taking the general character of the district, is it not the fact that there is not much fire-damp evolved from the mines?—The workings there are not yet very deep, and the seams are, for the most part, considerably inclined, which always facilitates drainage. On the whole, I should say that it is not a very fiery district; but as the mines increase in depth, I have no doubt they will be found to increase in their fiery nature.

4025. *Chairman.*] In general, in Staffordshire, is sufficient care taken to keep the air-ways sufficiently large?—I think not.

4026. Do you think that, in Staffordshire, the class of overlookers and underlookers is inferior to the class in other districts or equal to other districts, except Northumberland and Durham?—I think they are very inferior in South Staffordshire, and also in North Staffordshire.

4027. Do you think that a want of sufficient air-ways and defective ventilation exist generally in small collieries or in large collieries?—I think that the best ventilation is ordinarily in the largest collieries, because they are managed by men of a superior class.

4028. In South Staffordshire, are there generally two shafts, a down-cast shaft and up-cast shaft?—Almost invariably.

4029. Mr. *Child.*] Is that the case in North Staffordshire?—I think it is almost invariably, if not invariably.

4030. *Chairman.*] In your opinion, ought the air-ways in the mines in North and South Staffordshire to be equal to the sectional area of the pits?—I think that they ought to be larger than the sectional area, where a large quantity of air is required. The size of the air-ways must be according to the quantity of air which is required in the mine; but I do not think that the largest quantities of

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air can be obtained in mines, unless the aggregate sectional area of those air-ways is greatly larger than that of the shafts, because their length is so much greater.

4031. In all the districts of Staffordshire, instead of being larger, are they generally much smaller?—Yes. The amount of ventilation obtained in coal mines is usually limited more by want of proper capacity in the air-ways opened in them, than by inadequacy in the motive power employed. This would be found to be the greatest defect in all ill-ventilated collieries, if their statistics were separately examined and compared with those of the other class; collieries of small size, relying chiefly on natural ventilation for a supply of air, are, perhaps, those in which this impediment to its circulation exists to the greatest extent. In such districts as South Staffordshire, where there are a pair of shafts in every field, this means of ventilation would generally be sufficient; but in coal pits in this district it will frequently be found, that while the sectional area of the shafts is about 40 square feet for each shaft, the area of the air-ways in the pit does not exceed five or six square feet, or from one-sixth to one-eighth of the area of each shaft.

4032. In cases of that kind, would it not be immaterial what power of ventilation there was in the shaft, inasmuch as it would be impossible to travel through air-ways of that capacity?—It would be impossible for an adequate amount of air to travel through air-ways of that capacity.

4033. Can you institute a comparison between the relative proportions of cases of this kind and well-ventilated collieries?—If the relative proportions, which are shown in a case of this nature, be compared with those existing in any well-ventilated colliery, the defect will be clearer. For example, if we take the proportions to be found in the Hetton Colliery, between the aggregate sectional area of the ingoing air-currents and the sectional area of the up-cast shaft, the Blossom Pit, by which all those currents return to the surface, we shall find that the aggregate sectional area of the air-ways in the mine is to the sectional area of the up-cast as rather more than eight to one, being that of about 1,200 square feet to 150.

4034. The air-ways being eight times larger than the shaft?—Yes. In the former case the proportions were one to five or eight, in the latter they are eight to one.

4035. In your opinion, are the capacities of the air-ways in mines generally the root of all imperfect ventilation?—I think that the want of sufficient capacity in the air-ways of mines is at the root of all imperfect ventilation.

4036. Mr. *Child.*] Are the Committee to understand you to state, that you consider that in the mode of working small collieries artificial ventilation is even more required in them than it is in larger collieries?—It depends on the extent of ground which is worked from a pair of shafts. I do not think that artificial ventilation is always needed in the mines of South Staffordshire; for instance, where proper air-ways are opened, I think it is quite sufficient if the manager, at his discretion, puts a little fire in a grate at the bottom from time to time, as he may find to be necessary. Although the explosions which have taken place there have certainly occurred from the stagnation of the air current, yet they have generally occurred in mines where there were really no air-ways to keep up a proper circulation throughout all parts of the mine. The explosions have occurred in consequence of the men entering the mines in the morning ordinarily with naked lights, and without any preliminary examination. I think that a little better police would have prevented those explosions in every case of late years.

4037. Did you find the use of the safety-lamp general, or otherwise, in North and South Staffordshire?—It is scarcely used in South Staffordshire, except for the preliminary examination in the morning. It is used in some of the mines of North Staffordshire. In point of fact, the Thick coal is perhaps the only seam in which the Davy lamp proves inefficient where that seam is worked by the present mode of getting the coal, in chambers 30 feet high. The Davy lamp will not light up high enough in those mines.

Before concluding the subject of ventilation I may state, that last year I recommended the erection of machinery in South Wales, in a case in which special difficulty existed to the use of the furnace; and I have heard, within the last few days, from the viewer of the colliery, that he has found it answer the purpose, and that he is satisfied it will be a great saving, and give much better and larger ventilation than the furnace could have done, if it had been applied in that colliery; but it is a special case.

4038. *Chairman.*] That is Mr. Struvé's?—Yes.

4039. Mr. *Ingham.*] You have stated that in seams 30 feet in thickness you think

think the Davy lamp is inefficient, because it cannot cast the light high enough; do not the men work in successive stages?—I should recommend the working of that seam by long work in separate stages, and then the Davy lamp would be sufficient.

4040. Mr. *Child.*] What is the present mode?—The present mode is, working it in chambers 10 yards wide, 10 yards high, and 60 or 70 yards long, with pillars of coal standing between ranges of those chambers. The coal is usually worked in what are called two stalls abreast; that is, there are two openings 10 yards wide, separated by about three pillars 10 yards square, and the whole of the coal is cut up to the roof in those chambers, rendering it impossible to examine the roof, and ascertain whether it is safe, and causing very great loss of life from falls of coal.

4041. *Chairman.*] Is the use of machinery in Belgium very extensive?—It is extensive, which is caused perhaps in some degree by the use of wood in their shafts; their shafts are frequently lined with wood.

4042. And therefore it would be dangerous to use the furnace, for fear of setting the wood on fire?—Yes. The ventilation is usually weak in Belgium, but it is very carefully conducted; the currents always ascend; they are never conducted down again; the mine is divided into a good many districts; the currents are separate; they do not pass from one part of the mine into the other, and glass lamps are chiefly used.

4043. You have in your hand a list of the reports of different explosions which have taken place at various times?—Yes.

4044. Do those recorded facts furnish good data for conclusions as to the prevention of accidents?—I think they furnish the best data.

4045. Have you traced up those accidents, or have you merely read the reports of different inspectors?—I have visited nearly all the collieries myself; I have reported on several of the explosions myself; and I have examined with care, in other cases, the plans connected with the Reports published by Government, and presented to Parliament.

4046. Mr. *Child.*] Have you ascertained, either by your own inquiries or from the statements of others, the causes of those particular explosions?—I have.

4047. *Chairman*] You will put in these reports which you have in your hand, and if you desire to call the attention of the Committee to any points in them, you may do so now?—In the Haswell Colliery explosion, which is a colliery I have examined myself, I consider that the separation of the ingoing from the outgoing air was insufficient, and that the want of secure separation was the cause of the great loss of life which occurred from the after-damp in that pit; seven-eighths of the loss of life occurred from the after-damp.

4048. Mr. *Child.*] Is it not usually the case, that the loss of life is caused by the after-damp rather than by the explosion?—Always in a large explosion.

4049. *Chairman.*] There being two shafts?—Yes.

4050. Mr. *Child.*] Does not the explosion generate the after-damp?—The explosion generates carbonic acid to some extent, but the after-damp consists chiefly of nitrogen, with thick coal dust in the mine, which produces great difficulty to respiration. The after-damp is a compound of carbonic acid, nitrogen and aqueous vapour in an atmosphere of black dust.

4051. *Chairman.*] Nine-tenths of it being nitrogen, and nitrogen being of less specific gravity than the atmospheric air, would it principally lie at the top of the level instead of at the bottom?—I think that the oxygen of the atmosphere in that district of the pit is entirely absorbed by the explosion.

4052. Mr. *Child.*] Does a combination of these various gases then take place?—A combination of these various gases then fills the mine.

4053. *Chairman.*] At Jarrow there is only one pit?—Yes.

4054. A brattice shaft?—Yes; that is a species of insecurity of the same nature as the ineffectual separation between the air-ways in the pit.

4055. In your opinion, should a mine at any time be worked by a brattice shaft?—I think it is a very objectionable practice; and I reported, I think, to Sir George Grey, that in no case uncovered flame should be allowed below the surface where such a circumstance occurs.

4056. You reported at Risca and Jarrow?—At Risca on one occasion, but not at Jarrow. I have visited the Risca Colliery several times, and Jarrow once.

4057. And also the Eaglesbush?—I have visited Eaglesbush.

4058. Aberdare?—Yes.

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4059. Middle Dyffryn?—Yes.

4060. In all these cases, do you think that the evil of great loss of life was aggravated by the want of a sufficient separation of the air-current and the doors, and from the want of proper stoppings?—I think that in all these cases the loss of life was greatly aggravated by an imperfect division of the mine into districts, and by the connexion of all the ventilation of the mine together; so that any accident occurring in any part of the current, destroyed the continuity of the air-ways, and prevented the circulation from being continued.

4061. Is there anything else, with regard to these reports, to which you wish to direct the attention of the Committee?—I wish to direct the attention of the Committee principally to the dangerous mode of working coal which is practised in the Barnsley district, where the air-currents are carried unbroken throughout the mine from bank to bank, and from one goaf to the other, to the rise of that goaf, and where the men are in the habit of working in that current, which may be at any point explosive, with naked lights. The seam in which the explosions have occurred is generally inclined, and the fire-damp pours itself out at the upper edge of the goaf which is contiguous to the working bank, so that if there is any overflow from any goaf, it comes out immediately on the candles of the men.

4062. Mr. *Baird.*] Are explosions very frequent there?—Very frequent.

4063. *Chairman.*] Is there any other point in the reports to which you wish to allude?—There is no special point to which I wish to allude in those reports. I think that the manner in which the circumstances connected with each of them range themselves under certain invariable classes is very important in the inquiry.

4064. Taking the reports generally, to what do you attribute the accidents which have occurred in the particular cases?—In the first place, when seams of coal charged with fire-damp are worked, there is a constant discharge of that gas into the atmosphere of the mine from the whole surface of the coal exposed by working. This permanent yield of fire-damp may be diluted and carried off before it reaches the explosive point, by adequate ventilation. The quantity of fire-damp thus yielded is found to diminish as extended workings permit its escape and drainage. In the second place, when deep mines are first opened, this gas is found to exist in the seams of coal, and in the strata contiguous to them, under great pressure. The fissures and joints of the coal, and the planes of the strata, when exposed by working, present channels for its escape. In such mines, the condensed and imprisoned fire-damp overcomes at times the pressure upon it, and bursts suddenly in large volumes into the atmosphere of the mine. The only safeguard against the consequences of these sudden discharges, which overpower the most abundant ventilation, is to be found in the use of the Davy lamp, and in the general seclusion of the air currents of the mine from all contact with naked flame. In the third place, the exhausted workings of coal mines, in which the roof of the seam has broken down to a height corresponding to the quantity of coal extracted, form reservoirs from which the fire-damp can be only partially removed by ventilation. Unless air courses be provided to receive the overflow of this gas from these goaves, and to conduct it away to the upcast shaft without its mingling with the atmosphere of the mine, and unless the Davy lamp be employed, and naked lights excluded from those districts of the mine which are in contact with these goaves, they become a source of great danger. The frightful explosions which have occurred during the last few years in the Barnsley district of the Yorkshire coal field, have all been the result of a system of mining which produces a goaf of this nature, in contact with and at a lower level than the workings where the men are employed; whilst the employment of the Davy lamp, to guard against the irregularities of the overflow of fire-damp from the goaves so situated, has been neglected. In the fourth place, isolated parts of a mine, in which the distribution of the air currents is imperfect, may become filled with an explosive atmosphere; and, further, the quantity of fire-damp yielded at some points in a mine may be above the general average. The distribution of these currents must, therefore, be regular and general, and the quantity of air in each current adequate. It is highly important to restrict the extent of workings open at one time, as far as is consistent with the output of coal required. This will permit the ventilating currents, thus prevented from being dispersed over wide areas, to be distributed with regularity, and sufficient volumes of air will be available where they are needed. The general system of the mine ought to be so arranged as to provide for all changes in the ventilation

ventilation which may be required in any particular part. It appears from the foregoing considerations, that the security of collieries from explosion will not result in all cases from a large ventilation. From the manner in which fire-damp often exists in coal seams, and by derivation from those seams in the associated measure (namely, capable of great and sudden expansion when the pressure on it is removed), it sometimes bursts into coal mines in quantities which the amount of atmospheric air circulating in them cannot dilute below the explosive point, though that supply may be large, and amply sufficient under ordinary circumstances to render them safe. When a coal seam is found to be in this state, although by a proper arrangement of the workings and of the air-ways, the consequences of an explosion may be diminished and controlled, that occurrence can only be absolutely prevented by excluding the currents of the mine from all contact with flame, and by the exclusive use of the Davy lamp. The destruction of life, however, which results from an explosion, is usually far less from the burning and concussion of the actual blast, than from the after-damp which fills the mine when the explosion has passed; and this is unquestionably the consequence of defective arrangements in all those mines where this great loss of life from after-damp occurs. It appears, also, that the destructive effects of these accidents may be controlled and limited by arranging the workings of a colliery in such a manner as to divide those workings into separate districts, each district being isolated from the rest of the mine, and connected with the main ingoing and outcoming currents at two points only. The results of such an arrangement would be, first, to limit the extent of an explosion; and, secondly, to secure the ingoing currents to as great a distance as possible from the shafts, and to prevent the circulation being destroyed by the effects of the blast, so that the survivors, after the explosion, may be able to reach the unvitiated ingoing air. To carry out this system, and to attain these objects, the main passages of a coal mine, by which the currents of ingoing air are conducted to the workings where the men are employed, must be secured against the consequences of an explosion by substantial stoppings or barriers throughout their extent, up to the points were those currents enter the workings, wherever, in the progress of the operations, openings have been formed between them and the parallel exhausted workings, or the outgoing air channels. If, in consequence of the extent of the workings to be ventilated, it be found necessary to divide these air currents (technically, to split them) before they reach the extreme workings, that part of the current which is not thus abstracted, and is conducted to a more distant point, may be so conducted by means not liable, like doors, to immediate destruction by an explosion.

4065. Mr. *Child.*] You attribute that not to the door itself, but to the liability of the door to be broken or deranged by the explosion?—I do not attribute it further to the door, than inasmuch as the door is liable to be left open or to be destroyed.

4066. *Chairman.*] In your report of 1850, and also in a pamphlet published by you in 1853, you seem to place great confidence in the safety lamp; do you still retain your confidence in the safety lamp?—I feel the greatest confidence in the protection which a well-constructed safety lamp affords, but I do not wish to advocate the use of the Davy lamp to supersede ventilation; I wish that idea to be guarded against most fully. I have never been able, throughout my experience, to find any authenticated instance in which gas has exploded or ignited by the Davy lamp. In all the cases which I have investigated, it has arisen from the improper use of that lamp, or from the use of an imperfect lamp; for instance, in some districts of England, it is the practice to make those lamps with the gauze much too wide in the mesh. A gentleman exhibited to me the other day a lamp which he stated was the common lamp made at Wakefield, in which the gauze was evidently too wide; and it is in that district that several miners' accidents have recently been attributed to the Davy lamp. I have no doubt, having seen that lamp within the last few days, and heard that it was the Wakefield lamp, that the cause of those explosions is evident, and that they have occurred from an improperly constructed lamp.

4067. Mr. *Ingham.*] You have stated that explosions have arisen from an improper use of the Davy; what do you mean by "improper use"?—The continuing the use of the lamp when it is filled with flame, and becomes red-hot.

4068. *Chairman.*] Have you read the experiments of Mr. Nicholas Wood in the evidence which he has given before this Committee?—I have.

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4069. Do those experiments confirm your confidence in the safety lamp?—Most strongly.

4070. Looking at the results of the experiments of Mr. Nicholas Wood, is it your opinion that any kind of safety lamp which underwent the trial that he made is perfectly safe, and cannot be exploded under ordinary circumstances?—Yes.

4071. Mr. Nicholas Wood stated in his evidence, that it is necessary to reach a speed of 15 feet per second before the lamp will explode, and that the lamp must then be at a white heat; do you think those two things could possibly occur in ordinary practice?—I do not think that a clean lamp, with a gauze of sufficient fineness of iron wire, will explode gas under ordinary circumstances, provided that the cylinder of gauze be sufficiently small.

4072. Mr. *Child.*] You suppose that the miner would withdraw when he saw it full of flame?—He ought to be taught to do so.

4073. If he continued to use the lamp after it became full of flame, which you call an improper use of it, would it not be dangerous?—I consider that it would be improper, and unadvisable. Mr. Nicholas Wood's experiments tend to show that the lamp does not explode under such circumstances; but still he admits, that such a practice ought not to occur, and it is not what I should recommend.

4074. It is your opinion, that when such indications occur, the miner ought to withdraw?—It is my opinion that the miner ought to withdraw when such indications occur.

4075. *Chairman.*] Is it your opinion, that as an additional security to perfect ventilation in fiery mines, the use of the safety lamp ought to be enforced by law?—It is my opinion that in fiery mines the use of the safety lamp ought to be enforced by law; but I must be permitted to say also, that if I had the power, I should prohibit the mine to continue working when the lamp was ordinarily filled with flame. I should certainly prohibit such use of the lamp, as to permit the men to continue working when the lamp became filled with flame.

4076. Mr. *Child.*] You would prohibit working when the state of the lamp represented a very dangerous state of the mine?—Yes; I think that no colliery ought to be in that state.

4077. It ought to be sufficiently ventilated to prevent such an occurrence?—Yes.

4078. *Chairman.*] Have you read Mr. Nicholas Wood's opinions as to the mode of educating the officers of mines?—I have. I do not fully accord with them.

4079. Will you state in what particulars you differ?—I do not think that a certificate of education from a purely scientific institution, such as the School of Mines, is sufficient to prove that a man is competent to conduct a colliery. I cannot recommend the exacting a certificate of education in all cases, because I think the education may be obtained without it, and that it would be very inconvenient to miners in charge of mines to leave their work to come up to London, or to attend even a school in the provinces in all cases, in order to be permitted to conduct mines; such a difficulty would not exist in the case of young viewers of some property and possessing a certain station as is usually the case in Northumberland and Durham, but it would exist in all the other districts to a very great extent; there they are ordinarily of a class who cannot leave their work. I have a very strong opinion with regard to the necessity of education among the mining classes; in fact, in my report of 1850, I suggested to Sir George Grey that the same provisions might be applied to the mining population as were applied to the factory population, namely, that a certain amount of school attendance might be required on the part of all children under a certain age, and that opinion I adhere to fully.

4080. Whatever system of that kind might be recommended, it would only be prospective, and the improvement could not take place under a certain number of years?—Exactly; a generation must nearly pass away before the improvement could take place.

4081. And therefore, however excellent may be the system which has been recommended by Mr. Nicholas Wood, it would require a considerable time to develope itself fully, so that the improvement which he anticipates might be gained?—I think so.

4082. In the meantime, what would you recommend?—I would recommend the use of the Davy lamp in all fiery mines; but I think I should leave it in a great

great measure to the proprietor to determine whether his mine was fiery; I should leave him responsible for that determination.

4083. You would not give the inspector that power?—I would not give the inspector that power, if the present system of isolated and irresponsible inspection were continued.

4084. Do you approve of the present system of inspection?—I think it is quite irresponsible.

4085. In what way would you improve it?—I am fully aware that it is impossible, in the press of public business, that the reports of the inspectors should be duly considered by the office to which they are sent in London; and I think that the inspection of mines should have some central head, either by an association of the inspectors, and a chairman of the inspectors, or a constituted head, by a separate Board controlling the whole of the inspection. I do not think it can be effectual without that, and devoted exclusively to that object.

4086. Do not you think that if the inspection of mines were placed under the management of the Board of Trade, as railway inspection is at present, it would be an improvement?—I think that probably it would be an improvement; but it appears to me that the suggestions which Mr. Wood has made, with regard to the controlling power of the inspection, vested in such a scientific institution as the School of Mines, are not desirable. The organization of that school is too purely of a scientific character.

4087. Mr. Nicholas Wood stated in his evidence, in answer to Question 3,871, that he would put the inspection of mines under the same department as the railway inspection, that is, the Board of Trade; but that he would have a deputy or a chief inspector, who should consult with the professors of the School of Mines in case of any difficulty?—Mr. Wood stated, "The head of the Board of Trade, or his deputy, would, of course, consult with the professors of the School of Mines, in case of any difficulty." I do not think that the School of Mines, as at present organised, possesses that element of practical experience in mining which would enable it properly to judge in those matters; and, in support of that remark, I would refer to the well-known report which was made on the case of the Haswell explosion, some years ago, by scientific men of the highest eminence; and the impracticable nature of the suggestions which it contains, I think proves that the elements of practical experience and practical knowledge must be present in any body which is qualified to advise in the last resort upon the subject. That Report was made by Sir Charles Lyell, and Professor Faraday.

4088. The Committee understand that you differ from Mr. Nicholas Wood in having any reference whatever to the School of Mines?—I do not say that the School of Mines may not become such a body, but I mean to say that at the present time its organisation is of too purely a scientific character, and too devoid of the elements of practical experience and practical knowledge, to render it in my opinion an advisable body to be consulted in the last resort, notwithstanding the distinguished attainments of many of its professors.

4089. Will you state what, in your opinion, is the best way to improve the system of inspection?—I think that the inspection of coal mines would be most fittingly directed solely to the recording at stated times the condition of mines, to the investigation of particular cases of accidents, and to the offering of general advice; I think it would be very objectionable that any acts on the part of a member of the Government inspection should be such as to lessen or remove the responsibility of the proprietors themselves; I think it is important that that responsibility should be maintained to its fullest extent.

4090. Mr. *Child.*] You have been understood to state, that you would have the owners of mines the sole judges of the condition of the mines, and whether they were fiery or not?—I think I should leave them to judge of that, fixing a certain penalty if they disregarded the indications; I think it is desirable that there should be some power to prosecute the proprietor of a mine which is in an improperly ventilated condition, and that an action, as for nuisance, should be capable of being brought; and then it must be brought at the suggestion and recommendation of the inspector of the district, by the permission of the Board of Trade, or whatever body might be at the head of the inspection; I think that the most feasible plan would be to allow prosecutions, as in cases of nuisances, where a mine is in an improperly ventilated state; I think that, under a differently organised inspection, it might be perhaps advisable, after a mine has been reported for a certain time to be in a fiery state, to permit an order to go out from the

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Board of Trade that nothing but Davy lamps should be used in that mine; but I do not think that such an order ought to be solely entrusted to the discretion of the inspector; I think it should be made upon report to the head of the inspection.

4091. If an inspector were to visit a mine, and report that he had found that mine in a fiery state, and that the Davy lamp was not used, you would recommend that the Board of Trade or some other tribunal should issue an order for the use of the Davy lamp?—Yes.

4092. Would not that involve a considerable loss of time?—It certainly would involve a considerable loss of time in the first instance; but I am only recommending it, under a differently organised system of inspection, in which all the coal mines of this country, or those above a certain size, could be visited and reported on at fixed intervals; and then the Board of Trade would have a document always before it, to guide its judgment on that subject; I do not think that power could be advisedly placed anywhere, further than by a general enactment, which should leave the responsibility with the proprietors until that inspection was made systematic and complete, and until the results of that inspection were duly recorded at fixed intervals. I beg to call the attention of the Committee to the list of explosions which I have prepared, and which I think is very important (*The Witness delivered in the same.*)

Vide Appendix.

4093. *Chairman.*] Did those explosions, of which you have put in a list, involve the loss of about 1,100 lives?—Yes.

4094. In your opinion did the whole of the fatal accidents which have occurred, with a few exceptions, arise from the use of naked lights?—Yes; I have prepared the list which I have handed in with very great care, from all the documents to which I could gain access.

4095. Then the Committee are to understand that it is your opinion that in all cases where there is any danger of fire-damp, the use of the safety lamp ought to be imperatively enforced by law?—I think so.

4096. In your opinion, as the mines increase in depth and the danger consequently increases, is the use of safety lamps more particularly necessary?—I think so.

4097. Is there any other suggestion that you wish to make?—I think I have touched on all the main points to which I wish to bring the attention of the Committee. The chief reason for adopting the form which I have done in reporting the explosions, has been the opinion that when cases of accidents were examined carefully, they would all be found to range themselves under a few clearly defined causes; and, therefore, I thought it was important to place a consecutive list of explosions of that nature before the Committee.

4098. Although you have not determined upon any particular plan of inspection, your strong impression is, that nothing should be enacted which would interfere with the responsibility under which the coalowner ought to lie, and under which he does now lie?—I think not.

4099. You recommend that the inspection should go no further than a due regard to the safety of the men, leaving to the coal proprietor the power of working his colliery in the way he thinks best for his own profit?—I think that the action of the inspection should be limited to examinations, to reporting this examination, and to offering opinions and suggestions, which the coal proprietor may either adopt or disregard, in order that the responsibility may lie entirely upon him. I do not think that the appointment of sub-inspectors, according to a suggestion which has been made, would introduce an advisable element into the inspection. I think that the inspectors, in order to have weight and influence in the country, must be men of at least equal practical experience, and equal standing and position, with the proprietors whose mines they are intended to examine and to report upon. I think that a lowering of the character of inspection would be very injudicious and very unwise. I think that the greatest practical experience and the greatest weight of character ought to be a necessary qualification in all inspectors, or else their recommendations cannot be attended to, and the opinions they offer cannot be of value to practical men.

4100. Do you think that the present inspectors are men of the calibre to which you have alluded?—I observe that Mr. Nicholas Wood says, that probably some would be better for a little more practical knowledge.

4101. What is your own opinion?—I must subscribe, I think, to that opinion.

4102. Generally speaking, are the inspectors such men as you think are fitted to

to fulfil the duties which are imposed upon them?—I am not personally acquainted with all the inspectors.

4103. Mr. *Ingham.*] Do not you think that the very elevation of character and position which you have recommended in the inspectors, might rather indispose a working man to come to them with the same freedom to make representations with which he would come to a person who was more equal in condition to himself?—I think not.

4104. Mr. *Locke.*] You think it is desirable that the inspectors should be of such a class of persons that they would be beyond all temptation or influence, either on the part of the coalowner or any other person?—Yes.

4105. You give that as the reason why you think that sub-inspectors would be unnecessary, and (as has been suggested to the Committee) a class undesirable to place in such a situation?—That is one of my reasons.

4106. Do you think it is better that the superintendence should be less in detail, and more general, with a higher class of persons to perform the duties, than to extend it to deputies or sub-inspectors?—I think so.

4107. Do you know whether the present system, as it is carried out with the present number of inspectors, looking at its perfections and its imperfections, upon the whole works tolerably well, or would you like to see any change in the present system of inspection?—The number of inspectors is not adequate to visiting once a year all the coal mines in this country, or all the coal mines above a certain size; for I think it would be impossible to extend the inspection to every mine in the country.

4108. Have you formed an opinion as to the number of inspectors that would be necessary, according to your view of proper inspection?—I think that the number required would be from two to three times the present number; some districts would require three, and others two.

4109. Mr. *Child.*] You state that you think it is impossible to visit every mine?—I do not think it would be possible to visit every mine, including small mines, where perhaps five or 10 men are working.

4110. Can any inspection be adequate which does not visit all mines, inasmuch as the small mines are those which most require ventilation, generally speaking?—It is not in small mines that the most fatal accidents occur.

4111. Is it not generally found that small collieries are in the worst condition? They are not ordinarily the most dangerous, in so far as being fiery. The large mines are generally the most fiery. The small mines are imperfectly ventilated, and they have carbonic acid gas in them.

4112. You have stated that the greater majority of accidents occurred, not in the larger coal mines, but in second-rate mines?—I think in collieries occupying somewhat of a medium class; that is, they are usually large collieries, but not of the largest class, nor are they of the smallest class. If we take the principal explosions of late years, for instance, in the explosions in South Wales, those collieries are not equal in extent to some of the openings of the Dowlais Iron Company but they are large collieries.

4113. Mr. *Locke.*] Are the Committee to understand you to state, that according to your notion of inspection, every colliery, except some of the smaller ones, should be visited by an inspector at least once a year?—I think so, to form an efficient system.

4114. It has been stated that the inspection which is given by the present inspectors over the collieries of this country is once in four or five years; would it take that period to examine them all?—In some parts, perhaps it might; not in all.

4115. Do you consider that is an imperfect mode of inspection?—Certainly. Of course it is a matter to be ascertained, whether the system would not be too cumbrous, if it were made perfect.

4116. Are you acquainted with the views and dispositions of the coal proprietors, in reference to the inspectors?—I have always received the greatest attention; and especially when I was engaged in the preliminary Inquiry, I have always been treated with the utmost civility, except in a few isolated cases.

4117. Are you of opinion that the present inspection is likely to produce a state of feeling amongst coal proprietors which might eventually lead to less necessity for an extension of the inspection?—I do not know whether it is to be attributed to the inspection, but I think that such a feeling has in many cases been produced by the result of inquiries of late years. The inquiries before Parliament, and

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the general visits of the inspectors, have probably conduced to that result. On the other hand, in some districts I have unquestionably found the coal proprietors to be quite immoveable in their adherence to their old plans, and not to pay any attention to the representations which have been made to them.

4118. Is that an exception to the general rule, or does it apply to any large part of the coal proprietors?—I think it forms quite so large a part as to have a serious influence on the benefits derived from inspection.

4119. Is that one of the reasons which induce you to think that further inspection is necessary?—It is, if the system of inspection be continued.

4120. Do you think that the present system of inspection, if it were continued, would lead to that general acceptation on the part of proprietors which would render inspection almost unnecessary, by their participating the views of the inspectors?—I do not.

4121. For that reason, do you think that an extension of the inspection should take place?—Yes; but to produce that general attention, on the part of proprietors, I look more, I must confess, to the results of clearly defined responsibility in all cases of accidents, than to the action of any inspection, however it may be framed.

4122. Might not that responsibility exist now, under the present system of inspection?—It might.

4123. Do you think that considerable improvement has taken place generally in the management of mines, since the inspectors have been appointed?—No; I do not think that any improvement can be traced.

4124. Do you think that notwithstanding the proprietors of mines have, as a general rule, followed the recommendations of the inspectors, that has been attended with no great advantage?—I do not think they have generally followed the recommendations of the inspectors.

4125. You have been understood to state, that with the exception of some persons in some districts, you thought that proprietors had very generally listened to the representations, and had conformed to the recommendations of the inspectors?—That is not what I intended to convey by my answer; I misunderstood the question which was put to me; I understood it merely to refer to the common terms of intercourse between the proprietors and inspectors, and whether the inspectors were received with the ordinary courtesy.

4126. The question had reference not only to the courtesy of intercourse, but also to the adoption of any responsible recommendations on the part of the inspectors?—I do not think that has been the case.

4127. Will you state on what ground you expect any very great improvement from an increased inspection?—Merely from its being evident, in all cases of accidents, what was the state of the mine, from the recorded visit of the inspector at a certain time, the state of the mine from time to time, and the additional responsibility which the knowledge of that evidence being in existence would carry to the mind of the proprietor.

4128. Do you think that means of information are not at present to be derived, in consequence of the deficient number of inspectors?—I think it is not. My recommendation tends more to an improvement in the state of mines, which may be expected from adding to the responsibility of the proprietors, than to any improvement which would be derived from inspection. The increased regularity of inspection which I recommend, has reference chiefly to the effect it would have in fixing the responsibility of the proprietor, by showing the state in which his mine was at a certain period.

4129. Do you think that a further inspection would enable the Government, or the body whose duty it might be to prosecute a proprietor in case of an accident, the better to carry on that prosecution by having more information as to the state of the mine at the time of the accident?—It has been proposed that the use of the Davy lamp should be made compulsory in fiery mines. The recording the state of mines, would have reference, in the first place, to the enforcement of that precaution; and, in the second place, it would have reference to any prosecution which might be instituted against a proprietor, for not effectually ventilating his mines, for not using proper care, and for not employing competent agents; and those circumstances would all be stated by the inspector, in the record of his periodical visit.

4130. You would make that Report evidence upon such a prosecution?—I should certainly allow it to be brought forward.

4131. *Chairman.*]

4131. *Chairman.*] Have you anything further to state?—No.

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[*The Witness delivered in the following Statement:*]

Haswell Colliery.

Haswell.

April 1845 (Report, 1845), 14 killed by fire; 81 suffocated.

The in-going air was separated in this pit along the line of its course (coloured blue on the plan), from the out-going current returning in a contrary direction to the upcast shaft, by brick stoppings only, the stability of which was entirely inadequate to resist the shock of an explosion.

The ventilation insecure.

These stoppings were, doubtless, all blown out along the line of the main rolley-way, in the north-eastern districts, where the explosion took place. This destruction of the stoppings left all that part of the pit without ventilation after the explosion, to some distance to the south-west of letter A in the main rolley-way. It was at this point that the first dead bodies of the men suffocated by the after-damp were found, none of the victims having been burnt, except in the district surrounding letter M.

Was destroyed by the explosion.

This fact proves the great loss of life to have occurred from the destruction of the ventilation throughout this part of the pit, and that it must be attributed to the want of effectual separation between the air currents and the different divisions of the mine.

Seven-eighths perished by the after damp.

Jarrow Colliery.

Jarrow.

August 1845 (Reports, 1847), 41 killed.

This explosion occurred in one of the seams (the Low Main), worked by a single bratticed shaft, serving both for the downcast and the upcast.

One bratticed shaft only.

It was violent in its character, and destroyed the lower 40 yards of the brattice in the shaft. Only one individual survived the explosion in the Low Main workings.

The brattice destroyed.

The seam in which it occurred was fiery; one of the witnesses stated that the "pit had been making a great deal of gas." Naked lights, however, were used in it.

A fiery seam worked with naked lights.

The insecurity arising from the use of a bratticed shaft, is of the same nature as that which results from the want of effectual separation between the other air-ways of mines. Unless this separation be secure throughout the entire extent of the air-ways, great loss of life from after-damp will always be liable to occur.

Want of stability in the separation between the air currents is everywhere equally dangerous.

Risca Black Vein Pit.

Risca Black Vein Pit.

January 1846 (Reports, 1847), 35 killed. (These were the men working in the western part of the pit.)

In this pit the ventilation was entirely dependent on the separation in the currents, maintained by a great number of doors. The doors marked A, near the shafts, if left open or destroyed, permitted the downcast air to return immediately to the upcast shaft without entering the mine. Six other doors were to be found along the course of the west level, situated in the mouths of the various cross headings, about 100 yards from each other. The leaving open or destruction of any of these doors, caused the ventilation to be entirely intercepted beyond the point where it occurred.

The separation between the air currents dependent on doors.

The ventilation of each cross heading was dependent on numerous stall doors; if any of these were left open, the circulation of air in the cross heading would be intercepted in a corresponding manner.

The ventilation of the cross headings.

The upper ends, being the more elevated parts of these cross headings, always contained fire-damp. A. Gething, page 36, says that the place where he was working, the Monday previous to the explosion, was so full of fire-damp that he failed to get out after two or three hours' brushing. Although some lamps were used, the men worked chiefly with candles.

The ventilation imperfect and naked lights used.

The fire-damp is supposed to have ignited from a candle in either No. 4 or No. 5 cross-heading.

The explosion, where originating.

All the doors on which the ventilation was dependent were blown out, including those marked A., near the shafts. The circulation of air therefore ceased entirely throughout the western side of the pit immediately after the explosion; very few of the men who perished were killed by the explosion; they were suffocated by the after-damp, which they

The circulation ceased from the destruction of the doors.

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they had to pass through on their way to the shafts. The cessation of the ventilation, consequent on the destruction of the doors, prevented these men from reaching the shafts, or from being rescued, as it was impossible to pass through or to enter into the stagnant after-damp which filled the pit.

The ventilation ought not to be dependent on doors for its maintenance.

There is no necessity whatever that the ventilation of a pit should be dependent on doors for its security; they are costly, and imperfect substitutes for a properly arranged system of air-ways. The absence of proper air-ways renders an insecure system necessary, prevents the introduction of sufficient volumes of air, and also compels the use of that air after it becomes loaded with fire-damp. The probabilities of explosion are thus increased, and at the same time the fatal results which attend it.

Naked lights ought not to be employed in such a mine.

The employment of naked lights in a pit in the state in which this was proved to be at the period of this explosion, was highly objectionable.

Numerous lateral openings render an in-going air-current insecure.

When a large number of cross-headings forming lateral channels for the passage of the intake air into the return air-ways, are crowded together along the course of the main level or in-going air channel, great danger results from the liability of the circulation to interception at so many distant points.

The workings should be so arranged as to restrict their number, as connected with each in-going air-current.

It is always desirable, in a pit from which the out-put of coal is required to be large, that there should be several level ranges in simultaneous operation, so that as few lateral openings as possible may be connected with one main air-course at the same time; by this arrangement, the intake air may be carried securely up to the workings where the men are employed, and the pure in-going air reached without difficulty, after an explosion by the men endeavouring to escape.

Or means adopted to guard against the danger from this cause.

When this cannot be effected, and where all the workings in progress must be situated on one level, it is advisable to provide for the security of the greater portion of the intake air, by conducting it through a separate air-way, parallel to the main level, the level itself being ventilated by a split from the main body of air conducted into it by a securely gauged opening. This was necessary in such a pit, not only in order to form a secure air-channel, but also to conduct air in sufficient volume to the extreme workings, without its being obstructed by the numerous trams and horses constantly filling the main level.

The form of the airways opposed much resistance to the motion of the air.

The air circulating in the western division of this pit was everywhere confined in one single current to a tortuitous and insecure air-course, which ascended to a considerable height in the seam, and was then forced to descend again in each of the seven cross-headings situated on this side of the pit.

Other explosions in this pit.

There have been other explosions in this colliery, in 1842, 1847, 1848, 1849, 1853. Naked lights are still used it.

Eaglesbush.

Eaglesbush Colliery, Neath.

March 1848.—20 killed.

The difficulties in the ventilation of this colliery.

This colliery presented difficulties in ventilation from the mode in which the seam of coal was reached. This was not by shaft, but by an inclined drift following the seam of coal downwards on the dip, the nature of the surface not permitting the sinking of shafts in that direction.

A fiery mine, in which naked lights were used.

The seam of coal worked in this colliery was fiery. The quantity of air introduced into the mine was small, and liable to be irregular in quantity, as the ascending or return air-current was only rarified by passing it over a furnace situated on the surface, near the out-crop of the seam. Naked lights were employed in this colliery.

Ventilation is now effected by machinery.

Since the explosion a pair of Struvé's air-pumps have been erected. A larger and more regular supply of air is obtained by their action.

And with advantage.

This mine presented circumstances under which ventilation by machinery has been effected with decided advantage.

Lletty Shenkin.

Lletty Shenkin Colliery, near Aberdare.

August 1849.—52 killed.

The district is fiery.

This colliery is situated between the Old Dyffryn and the Middle Dyffryn collieries, in which 107 lives have also been lost by explosions in May 1845, December 1850, May 1852.

The

The plan of this colliery, published with my general Report of 1850, accompanied a report to Sir G. Grey on this explosion. Those parts of the main levels coloured dark blue in that plan denote the limits of the explosion. It occurred in the main in-going air-current in one of the levels. It destroyed the doors, forming on each side of these levels the separation between the intake and the return air. The effect of this was to cause the whole of the in-going air to return to the upcast shaft, through the deep cross heading marked D. C. H. 2, on the plan.

The ventilation was destroyed by the explosion.

Those parts of the workings where the men were employed are coloured yellow in the plan referred to. It will be seen, on reference to it, that the whole of the districts where they were engaged were connected in their ventilation, and affected by the explosion.

The whole of the men were involved in its consequences.

After the explosion, the men who endeavoured to escape from the workings had to pass for a distance of about a quarter of a mile through a stagnant atmosphere of after-damp. Very few were killed by the explosion; nearly all perished from suffocation.

The after-damp the cause of the great loss of life.

The fire-damp which caused the explosion entered the in-take air in the north level from some abandoned workings, lying between it and the deeper level to the south. It was known that these abandoned workings were full of fire-damp, but no means had been taken to seclude them from the intake air currents. On the contrary, a portion of the air in-going by the south level, was directed to sweep this fire-damp out of these workings into the main current in the north level, in which the explosion occurred.

The ingoing air-current exploded in the main level.

The conclusions presented to Sir G. Grey in this report were the following: "That the principles which ought first of all to be observed in arranging the air-ways of every mine had been overlooked, namely, the protection of the intake currents from any possibility of their being rendered explosive until they reached the workings where the men are employed; the isolation of each district of the workings, along with the system of air-courses belonging to it, so that an explosion may be only partial in its effects; and the ventilating of exhausted portions of the mine by such parts of the return air as are never traversed by naked lights. Naked lights were used in this pit."

The conclusions of the report on this accident.

Middle Dyffryn Colliery, near Aberdare, Glamorganshire.

Middle Dyffryn.

December 1850.—13 killed.

This pit is the next in the Aberdare valley to the deep of Lletty Shenkin. The workings had been recently commenced at the period of this explosion. They were in progress near to the shafts. No preliminary drivage had been made, although required to establish a large and secure ventilation, and to reduce in some degree by drainage, the pressure under which the fire-damp existed in a seam known to be highly charged with this gas.

The workings had recently commenced at the time of the explosion in December 1850.

In consequence of this neglect to open out adequate and secure air-ways in advance of the workings, the ventilation was dependent for its maintenance on the numerous doors which formed, throughout the pit, the only separation between the intake and return air-currents. It was also exposed to sudden and complete stoppage by falls of the roof constantly liable to occur, through a large extent of the single and insecure airway to which it was confined.

The ventilation was restricted from the want of proper airways.

The explosion appears to have taken place in consequence of a sudden discharge of fire-damp from the roof of the coal in one of the stalls, at the period of the first weight and extensive rupture of the strata above the coal which occurred in the pit.

This explosion, how originating.

The whole of the strata in this pit were highly charged with fire-damp under great pressure; the exposure of the air-currents in such a mine to any contact with flame was therefore highly objectionable, and was the cause not only of the explosion just spoken of, but also of a second in May 1852, by which 65 persons were killed.

A fiery mine, in which naked lights were used.

It is important in this inquiry to observe what were the conditions of this pit in which these consecutive explosions occurred. It was the deepest in the Aberdare Valley, the three deepest pits being this and the contiguous collieries already mentioned, the old Dyffryn and the Lletty Shenkin. To the deep, and on both sides of it, there is an unbroken tract of coal measures of immense extent, which have never been drained of any portion of the fire-damp with which these measures are highly charged.

At the time of the explosion it was the deepest winning in a maiden country.

The period at which these explosions have taken place successively in the Old Dyffryn, Lletty Shenkin, and the Middle Dyffryn Collieries, has been the period at which each of them was the deepest winning, or the deepest extensively worked winning in the Aberdare valley; it therefore occupied the position where the fire-damp pervading these deep unbroken coal measures was subjected to the greatest pressure, and found the only channel for escape.

This also was the case at the contiguous collieries at the periods when the explosions in them occurred.

Corresponding circumstances with reference to the surrounding district, exist in the Black Vein at Risca, and in the Eaglesbush Colliery.

Also at Risca and Eaglesbush.

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Between the period of the explosion of 1850 and 1852 no change had been made in the ventilation of the Middle Dyffryn Pit, except that of shutting out the pumping-shaft from its former connexion with the system. At the time of the explosion of 1852, the winding-shaft, divided into two parts by a timber-brattice, formed both the upcast and the downcast. The same neglect to drive out a connected system of airways to form permanent and secure channels for the ventilation, which has been remarked upon in the case of the first explosion, is to be observed on examination of the extended workings at the period of the second; the same imperfect and insecure separations by the interposition of doors between the ingoing and the outcoming air-currents existed every where throughout the pit.

No change had been made in the system of ventilation between the period of the first and the second explosion in May 1852.

The doors situated on the main levels, which formed the intake air-channels, amounting to 23 in number, in addition to fully an equal number of stall-doors; the insecurity of a system dependent on such arrangements, will be seen when the consequences of the explosion are examined.

The ventilation dependent on a large number of doors.

If return airways to receive the air ingoing by each level in its passage out of the mine had been driven out parallel to each level, at suitable distances from it, and if the cross-headings, from which the coal is worked, had been driven through from the levels to these airways, the air passing from the ingoing into the outcoming air currents through the workings connected with each cross-heading, might have been securely apportioned by gauging the mouth of every cross-heading where it entered the return airway.

The airways of a pit may be so arranged as to remove that source of danger.

Under such a system as that now described, an explosion could not have extended beyond the cross-heading in which it occurred, and the ventilation would not have been disturbed by it beyond these limits; within them it would have been restored immediately by the air resuming its usual course, and carrying the after-damp away from the survivors.

And the effects of an explosion limited in their extent.

At the period of the second explosion, a drift termed, No. 2, Deep Cross Heading, situated near the shaft of the pit, was in progress towards the south, in which direction it was entering the deep unworked coal-measures by which the colliery was bounded. The roof of this headway was weakened by a number of stalls driven out of it for the purpose of working temporarily some coal on both sides.

The explosion, where originating.

This headway was ventilated by a small split of air, which was returned from the face of the east level after receiving the fire-damp, which was discharged in considerable quantity in that level, and in some stalls near that point to the deep of the level. This current, after passing through this drift, was carried from it after a run of not more than 150 yards over the furnace situated near the upcast part of the winding shaft.

The ventilation of that part of the pit.

The explosion appears to have originated from a violent and large discharge of fire-damp, which occurred coincidently with extensive falls of the roof of the seam near the deep extremity of this dip heading, the position of which has just been described.

The explosion, how originating.

The amount of pressure on the fire-damp which discharged itself at the period of the explosion, is shown by the fact, that the roof was torn down suddenly with great violence, by it, to the height of about six yards, for a distance of many yards in length along the course of a joint traversing the measures.

From a sudden outbreak of fire-damp.

Notwithstanding the former explosion, which had also been occasioned by a sudden discharge of fire-damp, and the probability, from the known condition of the coal-seam, that other similar discharges would take place, this pit was working when it occurred with naked lights, the ventilation was weak, the air-currents were much loaded with fire-damp and the whole carried over the furnace.

Naked lights were still used, and all the returns carried over the furnace at the period of the second explosion.

Coal mines presenting the conditions described in this case, are always liable to outbreaks of fire-damp of this character as the excavation of the coal proceeds; no practical amount of ventilation will render such mines secure against explosion. This security can only be obtained by the use of the Davy lamp, and the seclusion of all the currents passing through the mine from contact with flame.

The air-currents ought to be secluded from all contact with flame in mines of this character.

The plan, which I now produce, marked No. 1, shows the system of ventilation in the Middle Dyffryn Pit at the time of this second explosion. The blue colour shows the course of the ingoing air-current. Nearly the whole of this air was conducted to the face of the east level, from which it travelled back in a contrary direction through the workings. The air traversing the workings, and returning to the upcast shaft, is coloured red. The pumping shaft, and the roads leading to it, which were shut out from the circulation, are coloured with Indian ink. The course of the air-currents is denoted by the direction of the arrows. The stalls where the men were working are coloured yellow.

The ventilation of pit. Plan, No. 1.

The point marked A in the plans, is that were the discharge of gas is supposed to have taken place; the explosion which ensued destroyed all the doors situated in or adjoining to the main levels, including those which shut out the pumping-shaft from any connexion with the ventilation. At the same time, the lower part of the brattice which divided the large winding shaft into downcast and upcast portions, was blown out, and it became the upcast on both sides, while the pumping shaft became the downcast.

The effect of the explosion.

The other plan which I also produce, marked No. 2, shows the state of the pit immediately after the explosion.

The state after the explosion. Plan, No 2.

The

(To face Page 68.)

MIDDLE DYFFRYN COLLIERY.

PLAN No. 1.

Intended to represent the state of the Pit before the Explosion, May 1852.

The ingoing Air is Colored ..... *Blue*
Outgoing ..... *Red*
Represents ..... *Doors*

Scale 2 Chains to an Inch.

J. Kenyon Blackwell

MIDDLE DYFFRYN COLLIERY.

PLAN Nº 2.

Intended to represent the state of the Pit after the Explosion, May 1852.

The ingoing Air is Colored _____ Blue.
The districts supposed to be filled with After-damp, after the Explosion;
are shaded with Indian Ink

The maintenance of the circulation of air in this pit was entirely dependent on the security of the doors, which, amounting to 23 in number, were fixed in the levels and in the lateral openings leading into these levels. The air circulating in the pit was liable to be intercepted at any of the points where these doors were situated, since the ingoing air-current might pass directly into the current returning to the upcast shaft, at any one of these points, leaving the district beyond that point without ventilation.

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The ventilation liable to be intercepted at each of the lateral openings closed by doors.

These doors were all swept away by the explosion, as shown in Plan No. 2, and the whole of that part of the pit, shaded with Indian ink in that Plan, appears to have been immediately filled by an atmosphere of after-damp, the circulation of air being restricted to the narrow limits, coloured blue, around the shafts.

The doors all swept away by the explosion.

It will be seen from an inspection of the Plan No. 2, how the men, endeavouring to escape from the working districts to the shafts, were intercepted in every direction by the atmosphere of after-damp which filled the levels, the only roads which they could traverse. Those only who came from the north-western districts were able to reach that part of the pit around the shafts containing air fitted to support life. All those who came from the east and from the north-east perished from suffocation in the east level.

The continuity of the airways being destroyed, the after-damp could not be removed.

It is important to observe how entirely unavailing any amount of ventilating power must be to convey air into any mine in which the doors or other barriers conducting that air, and forming the security for its circulation, are swept away, as in this case.

In such circumstances the ventilation must cease.

The ventilation of mines can only be maintained, or speedily restored in the event of explosion, in so far as the air-courses are of a permanent nature, and so arranged as to force the air to split itself, and to take a determinate course, without the intervention of doors or other easily destructible barriers.

The mode in which this may be guarded against.

Washington Colliery, Durham,

Washington Colliery.

19 August 1851—35 killed.

A Plan of the workings in the colliery where this explosion took place, is annexed to the report rendered by the Government inspector on this accident in 1851.

Plan in Report, 1851.

This Plan shows the workings in this colliery to have been carried on without system, and without arrangements for adequate and secure ventilation. The evidence taken at the inquest from men who had just quitted the pit, or who were quitting it at the time of the explosion, on account of the evidently explosive state of the air, shows the imperfect nature of the ventilation.

Ventilation imperfect and dangerous.

The district in this pit in which the explosion took place will be seen on reference to the Plan now mentioned. It will also be seen that the intake air entering this district, comprising the south and east workings, progressing in the whole coal, was only divided from the out-going or return air at important points, namely, at the junction of the main roads or rolley-ways leading to these workings, by a single row of brick stoppings; that the intake air was forced into the east workings, which it was the tendency of that current to leave unventilated by two single bearing doors placed separately in the east and south rolley-ways; and that generally, throughout the workings shown by this Plan, the ventilation was insecure and liable to interruption or total destruction.

Also liable to interruption or total destruction.

The above report states that six persons only were burned out of 35 who perished by the explosion. It would appear from the evidence adduced at the inquest, that all perished who were in that part of the workings where the explosion occurred. This might have been anticipated from the insecurity of the ventilation.

Five-sixths perished by after-damp.

Naked lights were used in this colliery, notwithstanding the dangerous state of the ventilation.

Naked lights used.

Nitshill Colliery, near Glasgow.

Nitshill.

March 1851—61 killed.

The Plan of the workings in this colliery, at the time of the explosion, will be found in the above report for 1851.

Plan in above Report.

The system on which the workings in this pit were conducted exhibits great defects, and was the obvious cause of the terrific explosion which occurred in it.

The ventilation bad in system.

The downcast air was carried in one unbroken current round all the workings; while the interior waste, amounting to 75 acres in extent, remained entirely unventilated. Fire-damp was liable to accumulate from falls of the roof in every part of this waste, but more especially

Confined to one current.

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cially in the faulty abandoned workings forming its boundary to the rise, on the north-east, through which the single current of air traversing the pit was carried on its passage to the north-west workings.

Liable to be entirely destroyed.

The unbroken current of air by which the pit was ventilated, was kept in its course by a single line of brick or board stoppings, liable to constant leakage, and to entire destruction in the event of an explosion. The unventilated condition of the large interior waste, rendered the extension of such an explosion, throughout the whole of the pit, in a high degree probable.

No means adopted to limit the effect of an explosion.

The workings of this pit were in no way subdivided, so as to restrict or control an explosion; nor were they so arranged as to reduce the extent of waste to be ventilated to its narrowest limits.

Naked lights used in a current liable to become explosive.

This pit furnishes an example of the consequences of the highly dangerous error committed in it, by carrying the single current of air circulating in it into the north-west workings, in which naked lights only were used, after that current had received the fire-damp yielded by the whole interior unventilated waste, including the faulty abandoned district to the north-east.

The system restricted the ventilation.

It was inevitable that the ventilation of a pit conducted on this system, should be restricted in its volume; for not only was this restriction produced by the air circulating in it being confined to one single unbroken current, but it was not possible that the men engaged in the working districts could bear a large circulation of air when directed on them in one current.

Danger of this system pointed out by Mr. Buddle.

The danger of this antiquated system was ably illustrated by Mr. Buddle, in his evidence before the Commons' Committee of 1835 (*Vide* 1994, and Plan No. 8, annexed to that Report).

ARDSLEY MAIN.

OAKS or ARDSLEY MAIN COLLIERY, near Barnsley.

March 1847—73 killed (Reports 1847).

The system of working has been attended by many explosions.

THE system adopted in this pit in working the eight feet Barnsley Main coal, resembles in its general features that followed in working the same bed in the other collieries of that district, where so many fatal accidents have occurred, including those in Darley Main, Warren Vale, and oher minor adjoining collieries.

The ventilation confined to one current.

The workings in this pit were scattered in various directions, but the whole were connected together in respect to ventilation. The air which circulated in this pit was carried in one unbroken current from one working district to another, until it was returned to the upcast shaft. The ingoing air, from the downcast shaft, was first conducted into the north workings, circulating round the goaf formed in the progress of these workings, and thence passed successively into each of the other working places, receiving the fire-damp yielded by the goaves in connexion with each of them, until it reached the extreme face of the south level, whence it returned to the upcast shaft.

The explosion, where originating.

The explosion appears to have originated on the north-west or rise side of the large south goaf, situated on the edge of the fault which passed through the middle of the main level, directed towards the south-west from the shafts.

The explosion destroyed the ventilation.

The force of the explosion extended on the north-west of this goaf, up to and around the shafts. It destroyed, throughout this district, all the stoppings which directed the circulation of the air, and made a breach in the walling between the upcast and downcast shafts, so that the whole of the ventilation ceased. This was the result of the want of sufficient strength in the separation between the shafts, and between the various air-channels.

The after-damp the cause of the great loss of life.

It was in this district surrounding the shafts that the great loss of life occurred, from the effects of the stagnant atmosphere of after-damp which, after the explosion, intercepted on every side, the men endeavouring to escape from the distant parts of the pit.

The confining the ventilation to one current produced an erroneous opinion of its sufficiency.

The evidence taken at the inquest shows, that although it appeared to the men themselves that the air circulating in this pit was sufficient in quantity, yet, since this opinion was only founded on the effect produced by the whole of the air being confined in one current, and thus directed in considerable volume on them, and on their lights, it is evident that such an opinion was erroneous.

Naked lights used in an air-current passing through dangerous districts.

Notwithstanding the prevalence of this erroneous opinion, which has frequently been expressed in similar cases, on equally false grounds, it is clear, from the evidence recorded at the inquest, that the air in the working places of the men was frequently found to be in an explosive state, and that part of the south goaf where the explosion occurred was, at that time, known to be in this state. (*Vide* examination of J. Littlewood, page 63, Reports 1847.) The men were, however, allowed to use naked lights at their own discretion.

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DARLEY MAIN.

DARLEY MAIN COLLIERY, near Barnsley.—Report 1849.

February 1847, 6 killed—January 1849, 75 killed.

Working the same seam in the same system as Ardsley Main.

THE Barnsley thick or main coal was worked in this pit. The workings in it, although varying in form and arrangement from those in this seam in the Ardsley Main Pit, were similar in the principle on which they were conducted, and in the character of their ventilation.

No means adopted to limit the effects of an explosion.

No subdivision or separation was attempted in the arrangement of these workings, for the purpose of controlling or limiting the effects of an explosion, by the effectual isolation of one part of them from another. The arrangement to secure the maintenance of the circulation were so inadequate to resist the effects of an explosion, that the occurrence of such an accident in any part became inevitably fatal to a great number of the men employed in these dangerous and ill arranged workings.

Naked lights used in air-currents liable to become explosive.

The same dangerous practice in the use of naked lights in air-currents, everywhere in immediate contact with numerous constantly enlarging goaves, from which fire-damp was discharging itself at all points, is to be remarked in connexion both with this and with the Ardsley Main Pit explosion.

The ventilation of this pit could not have been ordinarily above 7,000 or 8,000 cubic feet in volume per minute, because the velocity necessary to pass a larger quantity would have rendered the current highly inconvenient to the men. That quantity was totally inadequate for the ventilation of workings of the extent of those in this pit, in which 100 men were employed.

The explosion, where originating, and its effects.

The explosion originated in that part of the air-current which passed through the working places, and along and through the goaf, forming by their progress in the deep north-east angle of the mine, situated between the east boundary and the down-throw fault to the north. The movement of air caused by the ignition at this point, is supposed to have brought more fire-damp into the air-current from the goaves situated at the opposite or south-west extremity of this tract of workings; this fire-damp also exploded. The after-damp produced by this fire in a district near the downcast shaft, which would necessarily intercept the men endeavouring to escape from the more distant explosion, must have greatly increased the loss of life which occurred.

The loss of life from the after-damp not known, but evidently large.

The Report on this explosion does not give the relative numbers of the sufferers who perished by burning, and of those who in escaping fell victims to suffocation; nor does it show to what distance each individual who survived the blast had been able to escape before sinking under the effect of the after-damp. From the great length of that part of the current of the ingoing air which was affected by these explosions, and from the distance which each individual escaping the fire must have been compelled to pass through the after-damp before reaching the pure air near the downcast shaft, it is evident that a great part of the large loss of life which occurred must have resulted from suffocation.

WARREN VALE.

WARREN VALE COLLIERY, near Barnsley.

December 1851.—50 killed.

ELSCAR.

ELSCAR, COLLIERY, near Barnsley.

January 1853.—10 killed.

Causes analogous to those of the two preceding cases.

THE explosions in these collieries, and those which have taken place in other minor collieries of the Barnsley district, are analogous cases with similar results to those of which Ardsley and Darley Main Collieries furnish examples.

Limited and insecure system of ventilation.

The conditions under which all these explosions have occurred may be stated to be, in the first place, limited ventilation confined to single air currents, insecure throughout their course, because circulating in contact with goaves yielding fire-damp; and, in the second, the use of naked lights in such air currents.

Explosions in Lancashire.

AMONG the serious cases of Eexplosion in Lancashire, the following are the most known:

COPPULL.

COPPULL COLLIERY, near Chorley.

November 1846, 8 killed, (Reports 1847.)—May 1852, 32 killed.

Ventilation very limited and dangerous.

THIS Colliery, working the Arley Mine, a fiery seam of coal, was very imperfectly ventilated, both when examined by Mr. W. W. Smith in 1846, and by the writer in 1849; at this latter period the air in the deep downcast pit, filled the lamp with flame in several places;

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places; this air united to another portion which had not passed through the deep pit workings, was then carried to the workings connected with the upcast pit; the whole passed into this pit by a drift through a fault separating these pits, the area of which was only six square feet.

Naked lights used.

In this pit naked lights were everywhere used, in many places within five or six yards of an explosive atmosphere occupying the goaves forming by the working back of the pillars; the men were compelled to purchase their own lamps, or to work with candles.

Ince Hall.

Ince Hall Colliery, Arley Mine Pit.

February 1850, 4 killed.—March 1853, 50 killed.

A new and deep winning on a fiery seam.

This is an instance of a new winning on a fiery seam, at the considerable depth of 400 yards. This winning is much deeper than any previously made on this seam.

These conditions required the seclusion of the air-currents from contact with flame.

This seam, when I visited it in 1849, soon after the commencement of workings upon it, was so highly charged with fire-damp, as evidently to render the employment of naked lights, or exposure of the air currents of the mine to contact with flame, highly dangerous.

South Staffordshire.

Explosions in South Staffordshire.

Principal recent cases.

The causes of these have been already attended to. The principal cases given in my list of these accidents from 1846 to 1852, are

Rounds Green Colliery, November 1846, 19 killed: Heathfield Colliery, February 1848, 12 killed; Friary Field Colliery, June 1849, 15 killed; Whitehall Colliery, July 1851, 9 killed.

Naked lights and very imperfect ventilation.

These cases have all resulted from the use of naked lights, with little or no ventilation in the mine; the plan of the Rounds Green Colliery (Reports 1847) may be taken as an example of this class of collieries.

Goldsworthy Gurney, Esq., called in; and Examined.

G. Gurney, Esq.

4132. *Chairman.*] YOU are the inventor of the Steam Jet?—I am the inventor of the steam jet as applied to locomotion, and to coal mines; the principle of the œlipile is very old.

4133. Mr. *Locke.*] When was it first introduced?—Privately in 1816; it was publicly introduced in 1824-25.

4134. When did you first introduce it?—In 1825.

4135. Where did you introduce it?—At the Regent's Park. At the late Opthalmic Hospital, which was converted into a steam engine factory, experiments were made. It was introduced on the public roads in 1825 and 1826.

4136. Was it introduced anywhere prior to that time?—Yes.

4137. Where?—It was used in a locomotive engine in and about the Regent's Park, Edgeware, Stanmore; and in that direction.

4138. Are you aware that, prior to that time, the jet was used in a locomotive in the north of England?—No; Mr. Trevethick, and Mr. Davis Gilbert with myself introduced it into a chimney of a locomotive to get rid of the steam, but not to act as a jet; in that way it may have been introduced into the north of England in the year 1816.

4139. You do not know that the steam jet was employed in the north of England prior to that time?—I believe it was not.

4140. Are you aware that persons have asserted that it was so employed?—I have not heard so.

4141. *Chairman.*] Have you read the evidence of the experiments which have been made by Mr. Nicholas Wood, upon the relative value of the furnace and the steam jet?—I have read some part of it.

4142. In your opinion, were those experiments conducted in the mode best calculated to develope the power of the steam jet?—No; the experiments were altogether incapable of producing any power from the steam jet.

4143. Will you describe in what respect you consider them deficient?—They are deficient in consequence of an imperfection in the arrangements; by which means

means the displacement of the air or exhaustion produced by the steam jet is supplied from above the jet, instead of being drawn through the galleries of the mine. The same error was made in 1849; it was then pointed out to Mr. Wood, and he was referred to the South Shields Report upon it; he acknowledged that if he had seen that report he should have been aware of his error, and not have committed it; but he appears to have committed exactly the same error again; as a proof of it, if you look at his tables, you will find that the steam jet in no case does not produce more than 0·2 or 3·5ths; neither do I think it possible it could. I believe that the principle of steam jet was not brought into action at all in any of the experiments I have seen recorded.

4144. In what way, different from the way in which Mr. Nicholas Wood applied it, would you apply it, in order to develop its full power?—The application at the jet, must be so arranged to produce a pull or lift of the column to meet the requirements of the pit. If the drag of the mine is very considerable, the steam jet must then be differently applied; the area of the jet, or the area of column acted upon, must be changed.

4145. Mr. *Cayley*.] Will you explain in what the difference consists between the power obtained in ventilation by the steam jet and by the furnace?—The furnace acts by rarefying the column of air in the upcast shaft, by which the weight of that column is lightened, as compared to the weight of the downcast, and the difference between the weight of these columns produces the power; consequently the higher the degree of temperature in the upcast shaft, and the longer the column, the greater will be the power. The steam jet, on the contrary, acts by its mechanical action alone; it displaces the air in the front of it, thus producing an exhaustion behind, which exhaustion is filled by the air rushing to fill it; if it comes in easily from the sides or from above, it will not draw from the bottom; but if it is prevented from coming in from above or from the sides, it will pull from below. The amount of pull or power of the jet in producing an exhaustion below, depends on the size of the jet; the height or pressure of the steam; and the comparative area of the column on which the jet acts. The latter is most important; this condition has been overlooked in all the experiments which have been made by Mr. Wood; and so also in most of the experiments I have heard described in this room, with one exception, I think; an experiment which was made in Wales; where the jets were first applied to a certain amount of area, and only produced a certain amount of exhaustion; they were afterwards applied to a different sized column, which effected a ventilation, I think, of about 14,000 feet more.

4146. *Chairman*.] Where was that?—At Mr. Vivian's colliery; the areas of the upcast were reduced, by cylinders of five inches diameter; the jet and steam being the same, the increase of ventilation was raised from 14,000 to 21,000 cubic feet per minute, which shows a power of increase of three times, because the resistance of this quantity would be as the one quarter of its velocity. In that experiment, it will be observed that three times the power was produced from the same quantity of steam; and that is due entirely to the more perfect manner in which the steam was applied. This is the only experiment that really deserves the name of an experiment upon the jet; for although the others are called experiments, yet they really were no experiments on the principle of the jet.

4147. Mr. *Cayley*.] Do you conceive that Mr. Vivian, in trying his second experiment in a different form from his first experiment, began to appreciate the proper conditions to be observed?—Clearly; he saw the principle.

4148. And that he obtained a proportionate increase in power?—He produced three times the power; the jets were now not applied to produce their most power; because, if I rightly understood, the jets in some of the cylinders were $\frac{5}{16}$ths of an inch, and in others only $\frac{1}{8}$th of an inch in diameter; and they were square, I think. The large jet would overpower the small one, and reduce the actual pull to the minimum jet; the rest was thrown away. If he had applied jets of the same size they would not have acted against each other; they would have acted in unison, and the amount of ventilation would have been considerably higher. If you look at these numbers, seeing that the resistance is as the square of the velocity, supposing that the conditions are precisely the same, and taking the height by the water-gauge as a measure of power, if it stood at an inch in one case, it would stand at three inches in the other. I call attention particularly to this experiment, because it is the only one which bears upon the true principle of the steam jet.

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4149. These are experiments which have been given to this Committee by Mr. Gray?—Yes.

4150. Have you seen his evidence?—No.

4151. Do you believe that if those experiments which have been deposed to by Mr. Gray, as having taken place in Mr. Vivian's pit, had been more properly applied than they were in the second experiment, a much greater power would have been obtained than was produced?—Certainly; by reducing the areas, he might obtain any power.

4152. *Chairman.*] The areas of the cylinders?—Vary inversely the areas of the jets and cylinders, and by that means you arrive at any power you please; you may rise the water gauge to the extent of 15 or 16 feet of water.

4153. Would it not be possible to reduce the areas of the cylinders so much, that the jet of steam would fill the whole of the cylinders, and that there would be no vacuum to allow the air to go up?—If the test cylinder was as small as the jet.

4154. Would you make no allowance for the expansion of the steam?—Not the slightest; the expansion of the steam has nothing to do with the question; the exhaustion is effected behind it. The steam that is driven up by the jet, mixed with air, becomes a more perfect piston, and therefore becomes more effective for the jet to act on. If the cylinders be too large, the air and steam mixed in them will come back again, and act like the leaky piston of an air-pump, and destroy the vacuum; to attempt to produce a power by the steam jet without a proper proportion of area in front, you might as well attempt to work a high-pressure engine without a piston; it is absurd.

4155. Mr. *Cayley.*] What is the greatest degree of effect on the water-gauge you have ever known produced by the furnace system?—By the furnace system, I think, from 2 to 2 ½ inches is the greatest extent.

4156. If Mr. Wood has stated that about three inches is the greatest effect on the water-gauge by the furnace system, do you conceive that is the truth?—Yes; I am bound to think so; it would be very difficult to keep up three inches, because the pull increasing to such an extent, would have a very strong tendency, even in the furnace, to pull the air partially backward into this partial vacuum created by the rarefaction.

4157. Do you mean that there would be a retrograde motion of the air?—The air could not come on very readily through the mine, consequently it would find its way by any easier passages, if any existed; air in all heated columns produces what are called "retrograde series;" it passes a certain distance, and then coils back again, by which an eddy is formed from point to point, leaving a portion of the current running from the bottom to the top of the upcast, just as you see in a river; the eddy becomes more or less as the sides are unequal, and the bed of the river more or less level. If you look along the Thames when the tide is going down, you will see a black mark, which indicates an eddy on both sides, running up, of different widths; and, if you look closely into it, you will see these different rates and intensities are governed by the width of the river, its level, and the rate of run. Every boatman knows the value of an eddy.

4158. In obtaining an accession of power by means of the furnace, does the ventilation meet with any resistance in the drag of the air?—The drag will be as the square of the velocity at the minimum. Some say it is as the cubes; but I believe that the squares of the velocities is nearer the true increase of resistance. To that, however, must be added the *vena contracta*, which occurs more or less in all workings; so that the squares of the velocities may be taken as the *minimum* proportion of increase.

4159. Will you explain what you mean by the *vena contracta*?—It is the retrograde at the end of a narrow opening; for instance, at the end of a water-pipe the *vena contracta* acts very powerfully; and if that pipe were of different areas in its length, the *vena contracta* would act at every increase.

4160. If, by means of the furnace system, you obtain an increased effect on the water-gauge, say from one to two inches, that is obtained at a very considerable increase of the resistance to the ventilation of what is called the drag?—The drag would be indicated by a proportionate disturbance of the water-level. If the water-level is two inches in one case, and one inch in the other, it simply shows that the drag is double.

4161. Would the increased power of ventilation, from increasing the intensity of the furnace, be in the arithmetical ratio, and the drag be increased at the same

same time in the geometrical ratio?—The drag of the pit increases as the square of the velocity, the exhaustion of the furnace directly as the temperature.

4162. If the drag increases in so much greater a ratio than the pull, must it not result that there is a limit to the furnace system of ventilation?—Certainly.

4163. Explain why that would not apply in an equal degree, or with similar power, to obstructions in the case of the steam jet?—The drag increases in the same ratio, but as the pull of the jet may be made to overcome it, no matter what its amount may be, there is virtually no limit. The jet acts not on the great column which with the furnace is essential, but on a special column fitted for the occasion; like the cylinder or cylinders spoken of by Mr. Gray.

4164. Inasmuch as you state that the limit to the furnace appears to be at three inches of the water-gauge, do you believe that the same limit applies to the steam jet?—No; this limit of the furnace is occasioned by the size of the upcast shaft; this size shaft is a condition necessary to the working of the furnace, which cannot be changed; if it could be changed at pleasure, the pull of the furnace could be increased; but as you cannot reduce the area of a coal-mine upcast shaft to such a size as would prevent after a certain amount of exhaustion, it being filled from above instead of from below, the furnace stops. There is another cause of limit to the furnace, which perhaps I need not now only mention, namely, that the quantity of air passing must be heated to a given temperature, by a given fire; these we will suppose to be constant quantities; now, the temperature of the air must be increased if it be made to pull more in a direct ratio with its power of buoyancy; this cannot be, because the fire is a constant quantity; to obtain double the temperature, you must have double the fire, or one-half the air, and by that means the quantity of ventilation necessary goes backward, so as at last to come to its limit. Supposing you have 20,000 cubic feet of air to be raised to 100° of temperature, and supposing your fire is just sufficient to do it, it is self-evident that you cannot raise the same quantity of air to 200° of temperature; you can only raise half the quantity, to the same degree of temperature; it is true half the quantity will produce a greater disturbance of the water-gauge, but the quantity of air coming through the pit will be reduced 50 per cent.

4165. Will you explain to the Committee in what way that tendency to the limit of ventilation by the drag can be overcome by the steam jet?—You can reduce the column lifted to such a size that the steam jet will drive it, no matter what its pull backwards, or resistance, may be. I believe it is stated in the evidence of Mr. Cowie (a senior wrangler at Cambridge), before the Committee of the House of Lords in 1849, that it might be carried to any practical extent.

4166. In what way have the previous experiments failed to produce such a power, and in what way, practically, would you adapt the steam jet so as to obtain that power, if you had the conduct of the experiments?—It has failed in consequence of not attending to a very simple condition published in the South Shields Committee, where it was first proposed; namely, that "The whole column must be lifted;" and prevented from returning.

4167. How would you overcome that practical want of adaptation of the steam jet?—By a disc, or cylinder, or "Necking the shaft" as it is called, so as to lesson the column and prevent the return.

4168. Would you fill the area of the upcast, say with plates, and then pierce it in various places, for the jets to go through?—No; but by reducing the area of the shaft, as shown in a diagram published in the Report of the Lords, allowing the opening to be of such size that the power of the jet shall lift it so as to overcome the drag of the pit whatever it be; if it does not overcome the drag of the pit, it can be of no use.

4169. Is the object of the water-gauge to ascertain what degree of vacuum is formed in the upcast?—Yes.

4170. If the water-gauge can be affected by the rarefaction under the furnace system only to the extent of two or three inches, showing approximation towards a vacuum, the vacuum being probably represented by the figures 33, does it appear to you, from all you have heard, that the nearest approximation to a vacuum produced by the furnace is three inches out of 33 feet?—I never heard of so much as that being produced in practice.

4171. Properly applied, what effect on the water-gauge, that is, how near an approximation towards the 33 feet, which represents the vacuum, could be produced

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by the steam jet?—As much as 300 or 400 inches; there is no practical limit. Possibly this assertion may be considered speculative, but it is practically true.

4172. You believe in practice, you could obtain 300 or 400 inches of the water gauge, by means of the steam jet, if you applied it properly?—Certainly, if it was wanted.

4173. How many feet does that represent?— I think 25 feet to 33.

4174. Mr. *Locke*.] What amount of vacuum could be obtained?—Practically, 25 feet of water.

4175. Do you mean practically or experimentally?—I do not mean in a coal pit. In practice, for a particular purpose, 24 inches of mercury disturbance, which is equal to about 24 feet of water, has been obtained.

4176. Will you state the purpose for which this experiment was made?—This experiment was made for the purpose of dry-cupping. It was done in a case of serious illness, to produce an exhaustion similar to the cupping glass, and to draw the blood to a particular part of the system. Practically, they have produced about eight inches of water gauge in a coal shaft, and 24 feet for refining silver.

4177. Mr. *Cayley*.] Do you remember the experiments with the steam jet last year at the Polytechnic?—I do.

4178. What was the effect on the water gauge produced by the steam jet there?—I think, to the best of my recollection, it was 18 inches of mercury, which is equal to about 18 feet of water.

4179. That being the experimental power of the steam jet on the water gauge, how much of that approximation towards a vacuum do you think may be obtained in a coal pit?—You could easily obtain an exhaustion of six, or eight, or 10 inches of water gauge disturbance; but as it is more than likely that you would never require that amount of pull through a pit, in practice I should fix the jets in large workings and long galleries to produce a power of about four or six inches of water, and work it up to the drag required, whatever it might be. You would then always have a power in reserve; you would have a power of six to eight inches of water gauge, when possibly the drag of the mine might not amount to more than two or three inches; and in such a case you would be certain to command ventilation against all practical contingencies; and interference from atmospheric changes.

4180. Do you believe that one of the beneficial effects of the steam jet, as compared with the furnace, is that it has a power in excess of that which is required for practical purposes, which under extraordinary circumstances could be suddenly brought into play, and might materially diminish the danger which suddenly arises in mines?—There is no doubt of it.

4181. Do you think that one of the beneficial effects of the steam jet is indicated by your last answer?—Yes; it is capable of producing a power which cannot be produced from the ordinary furnaces as they are now constructed; which power, you might possibly want under peculiar circumstances.

4182. Is it not often the case that there are sudden outbursts of gas in a mine by the falling in of a roof?—Yes.

4183. Under those circumstances do not explosions often occur?—Frequently.

4184. Would it not, in your opinion, be a great advantage to produce, at such a critical moment, a great temporary accession to the ventilating power?—Yes; and you would have this power at command, provided you had the steam jet placed to produce six or eight inches of disturbance of the water gauge.

4185. Would it not also, in your opinion, be a great additional safety, if the steam jet apparatus were placed at the top of the downcast shaft, for occasional use, in case of an explosion?—I think it would; but it is more than likely, that being unprepared for an explosion, the steam might not be ready.

4186. Is it not the fact, that in the dreadful explosions which have occurred, more persons have suffered by the after-damp than by the fire-damp?—Yes.

4187. Is not the after-damp simply the absence of fresh air?—The after-damp is a mixture of carbonic acid and nitrogen; the want of oxygen is fatal to life.

4188. Is it not often the case that it is not immediately fatal to life?—It depends upon its degree of perfect formation; if it is imperfectly formed, and there is a portion of oxygen remaining free, life may be supported for some time; but if it is perfectly formed, and the whole of the oxygen is combined, it kills instantly.

4189. When they have been able to penetrate into the mine within three or four hours after the explosion, have they not often found bodies in a senseless state, but not actually dead?—Yes; cases have been known, I believe, where persons

persons have lived for some hours, and sometimes for days, before the fire-damp has reached them; for the fire-damp does not go all over the mine at once; it finds its way, under the laws of diffusion of gases, after a time, into the extreme working, provided there is no ventilation. Unfortunately, when those explosions happen, the ventilation is destroyed by the breaking down the doors and brattices.

4190. Even where the fire-damp has been evidently the cause of death, have there not been strewn about the galleries bodies not actually dead, but merely senseless, and subsequently recovered?—Yes; cases have been known where men have gone into a *cul de sac*, where the fire-damp has not reached them, and they have recovered after some days.

4191. Have some been found in various degrees of approximation towards death?—Yes.

4192. If they had not been discovered within three or four hours, would they not have died?—Yes, some cases.

4193. Then would it not be a great security to life, if there were a power, like the steam jet, at the top of the downcast, which would drive down mechanically fresh air into the pit, to enable those persons to recover, when other persons could not get down into the pit to rescue them?—Certainly; if a jet at the upcast were made to pull the fire-damp out, fresh air would find its way through.

4194. Under the circumstances of those explosions, would not the same thing apply to the steam jet by its being blown to pieces?—No; the doors and stoppings would most likely be blown down; and in that case, the air would run directly through those stoppings from the downcast to the upcast; that difficulty would not be overcome by blowing air down the downcast.

4195. In case of an explosion, would you place the steam jet at the top of the upcast or at the bottom of the upcast?—At the top of the downcast, if you wanted to blow fresh air down; but the doubt is whether fresh air would reach the spot of danger. That would depend on the condition of the pit. The pit should be so formed as to prevent as little disturbance as possible of doors and stoppings in case of an explosion.

4196. You have been understood to state that the steam jet acts mechanically by driving the whole column of air up the upcast as nearly as possible; and that the more it does that the nearer is the approach to a vacuum, and the nearer the approach to a vacuum the greater tendency there is in the air in the mine to follow that?—Clearly.

4197. You think that the increased ventilation which you would attribute to the steam jet, could be achieved by the steam jet, if it were properly applied?—Certainly; I have no doubt of it.

4198. You have stated that the power of the furnace depends upon the condition of the area of the shaft with its depth?—Yes.

4199. At a given depth does the furnace system become very powerful?—The deeper the pit, the more powerful it becomes.

4200. If you compare the expense of the two systems, does the furnace system at a very great depth, become the cheaper system of the two?—I think so; at a certain depth you could get no available power from the furnace.

4201. What do you mean by "a certain depth"?—Low shallow pits.

4202. *Chairman.*] State what you mean by "low shallow pits"?—200 feet is a shallow pit.

4203. Mr. *Cayley.*] When a pit is so deep as to go beyond 200 feet, and approximate to 1,000 feet, the nearer it approaches to 1,000 feet the greater will the power of the furnace become?—Certainly.

4204. If you wanted only a given amount of ventilation, in a deep pit, might the furnace system be the cheapest of the two, and perhaps be perfectly efficient?—Certainly.

4205. But in shallow pits, of 200 feet, or under 200 feet in depth, do you think that the steam jet is a more secure power to rely upon than the furnace system?—Certainly. The steam jet, acting independent of depth of column, would possess the same power in a shallow pit as in a deep one. I refer to some experiments which were given in 1849, where the furnace had little or no power at 10 fathoms; but the jet produced considerable power.

4206. In deep mines, may not the working be so extensive that, notwithstanding the depth of the mine, and the draught of chimney, the health of the miners requires even a more powerful system of ventilation than that which is given by the furnace?—It may require a stronger pull to overcome the drag than

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the furnace could produce; any increase of ventilation increases very rapidly the drag, which could not be overcome by the furnace, as now applied.

4207. What is your opinion as to the comparative expense of the two systems of ventilation?—To a certain depth the steam jet is the most economical, as a matter of expense; but below that depth the furnace is the cheapest up to a certain point. I may observe that I have the highest respect for the furnace. I think it is a beautiful application for ventilation, and it is one well calculated for coal mines generally; but there is a limit to it, and beyond that limit it cannot be carried in case it is wanted; very frequently that limit is dangerous, and you then require a power beyond it; and in such a case you must either have a mechanical power, such as the air-pump, the fan, the steam jet, or some similar power so as to produce a greater pull or disturbance of the water-gauge.

4208. In very extensive workings, even in the deepest pits, do you think it is possible, although the furnace is the cheaper system, that the steam jet may occasionally be required for the purpose of furnishing a greater power?—I think it would be very useful, and in some cases essentially beneficial, if applied in conjunction to assist the furnace; it must be differently applied than ever as yet been.

4209. Have you examined the calculations which Mr. Wood has given in his book?—I have looked through some of the tables.

4210. What have you to say to those calculations?—There is not a single table in which you cannot find discrepancies.

4211. Can you point out some of those discrepancies?—I have no doubt I can do so. I will show—first permit me by reference to them—that there has been no available disturbance produced on the water-gauge by the steam jet; because it will corroborate my previous statement, that there really was no such power. The table which was pointed out to me when I attended this Committee a few days since, is No. 21, page 64. The disturbance by the steam jet at 10 minutes after eight, was stated by Mr. Wood, to be eleven-tenths. It will be observed that the furnace was on at the time and produced ten-tenths of this disturbance; so that there was only one-tenth due to the jet. In the next line you find there is half a tenth less when the jets are taken off, so that half a tenth was only due to the jets. The greatest disturbance I have found in the tables, I have looked at, is about three-tenths by the jets. I think that three-tenths is very likely, partly due to boiler fires, if you will look at the table to which my attention is called by the Committee, you will find that out of the eleven-tenths there given to the jet one-tenth only due to the jet.

4212. What conclusion do you draw from that?—That there was no action of the principle of the jet. Unless the jet produced a greater power than the furnace, when they were together, it could not assist the ventilation. If both were producing eleven-tenths separate, and both in action that would have produced no more ventilation; but the jet alone only producing only a tenth, could do nothing; it was producing no disturbance. If we take the size of the jets, and the areas to be lifted, we shall find that a power equal to one or two tenths was the extreme that could be expected from it; the jets may be said to have done nothing in this table. In Table 16, page 59, the jets alone, it is said, produced 0·4, and the quantity of ventilation was 49,254 cubic feet per minute. At one o'clock the furnace alone was put on, and that produced a disturbance of from 0·8 to 0·9 of the water gauge. That is just double what it was before. If you take the quantity of air (the condition of the pit, I presume, remained the same) to be as the square root of the water gauge, it ought to give you a very different quantity than that shown in the table; 94,000 is nearly double 49,000. Here the increase is arithmetical with the pressure gauge, it should be as the square root! If you go on with the same table, you find that the temperature at one o'clock in the upcast was 180°, and that at three o'clock it was 272° by the same furnace; and yet the disturbance of the water gauge, only rises $\frac{11}{10}$ths or $\frac{12}{10}$ths. I think there must be some mistake in the numbers.

4213. Mr. *Locke*.] In speaking of the temperature of 272°, you are speaking of the upcast at 65 fathoms?—Yes; I presume the temperature of the shaft is a measure of its power on the water gauge.

4214. Do you observe that it is only 210° at a depth of 10 fathoms?—Yes; but you will find it 188° in the other line.

4215. Is the difference between 188° and 210°, so disproportionate as the figures which you have already stated to the Committee?—I take them as I find them.

4216. Are

4216. Are you not taking the temperature at one particular depth from the shaft, and omitting the temperature at another depth from the shaft?—I have not taken the second line, because I consider this the temperature of the shaft.

4217. Is there not much less discrepancy at one depth of the shaft than that which you have pointed out?—Yes; but not a great deal.

4218. Is not the difference between 210° and 272° very considerable?—Sixty-two degrees is the difference; the temperature of air was heated at one part of the upcast to 210°, and at another part of the upcast to 272°; and to 188° in one part, and to 180° in the other. The mean should be taken.

4219. Would you not rather take the lowest temperature as being the measure of increase?—No; I take the temperature in the way it is expressed here.

4220. In estimating the quantity of air passing up the shaft, would you not take the lowest temperature rather than the highest?—I take it as it is recorded.

4221. *Chairman.*] Would you, or not, take it at the lowest?—No.

4222. Mr. *Locke.*] Do you think that the lower temperature, which is a throttle valve to the air passing in a shaft, is not the point at which you ought to take the quantity of air which is passing?—The temperature of the shaft is the measure of the weight of its column of air.

4223. When you find that the temperature is so materially different as 272° and 210°, do you mean to state that you have assumed the increase in the quantity of air in the discrepancies in Mr. Wood's figures, by insisting on taking the higher temperature, and not the lower temperature?—I take the temperature as registered at the depth of 65 fathoms.

4224. Do you think it is fair to do that without taking the temperature at 10 fathoms?—Without an explanation I would.

4225. Do you think it is necessary to have any explanation, judging fairly of a table of this kind?—There is a discrepancy in the temperature, which shows that the numbers are not very accurate.

4226. Is there any discrepancy, or any difficulty, in adjusting the quantities of air from the temperature of 10 fathoms?—Yes; and I know how it happened.

4227. Do you think that the difference between 188° and 210° is so great that there ought to have been a larger increase in the quantity of air than appears in the table from 94,000 to 105,000 feet?—Certainly. The reduction of the temperature is owing to that which I explained in a former part of my evidence. The temperature is frequently reduced to a considerable depth by a series of eddies passing down; and hence the temperature of 272° in the one case, and 210° in the other. The 272° is the temperature of the air passing the furnace; the 210° is the temperature of the air after it has been reduced by mixture from above by a series of eddies forming from the external air in the upcast, and extending so far down. There is no doubt about that; it is well known to men acquainted with the subject. The 272° is the temperature of air, a certain distance up the upcast, above the furnace, and it is the measure to which the whole of the air ought to have been raised. According to Table 14, the jets only produced a disturbance of 0·3, and the furnace produced a disturbance of 0·9; so that the furnace represents a power of 0·9, and the jets 0·3; consequently the jets in the experiment of which this table is a record, could be of no use.

4228. You are aware that Mr. Wood stated, in his evidence before the Committee, that they did act, and you are aware that these tables show that the result was produced?—Yes.

4229. Have you any other means of judging that they did not act than your opinion?—Yes; from the tables themselves; I do not think they acted at all; I think Mr. Wood is mistaken in giving the power of the jet; I do not think the jet had any available power in those experiments.

4230. Then you think that, in point of fact, the increase of the quantity from 32,000 cubic feet to 37,000 cubic feet, was not owing to the application of the jets at all?—No.

4231. You do not attribute the increase of 5,000 feet to the influence of the jet?—No.

4232–3. To what is it owing?—To the temperature.

4234. You think it is owing to the temperature?—Yes; the temperature is 161° in the one case, and only 77° in the other; consequently the increase of temperature, which is very nearly 100°, accounts for the increase of pull.

4235. What is the difference in temperature?—Eighty-four degrees.

4236. With what are you comparing the 161°?—Seventy-seven degrees.

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4237. That is where the jets were employed ?—Yes.

4238. Ought you not rather to compare it with the temperature where the furnace was employed ?—No ; you are speaking of the comparative power of the jet alone ; you say that the ventilation increases to 77,000 cubic feet ; and I say the increase is due to the temperature.

4239. You are aware that the temperature was 132° and not 77° when the furnace only was employed, and that the temperature was increased from 132° to 161° when the steam jets were employed ; is not that the statement in the table ?—Yes ; at 21 minutes after 9, 161° is the temperature.

4240. Are you comparing the furnace only with the jets and furnace ?—I am answering your question, whether the increase of temperature was due to the jets ; and I say that it was not due to the jets ; but that it was due to the increase of temperature.

4241. You have stated that where the furnace was employed, in your opinion, no result whatever arose from the application of the jets. In Table 14, you will find that where the temperature was 132°, and the furnace only was employed, the quantity of air passed was 33,000 and odd cubic feet per minute ; and I want you to compare that result with the result which follows where the jet was put on to the furnace, and where the temperature was 161°, and the increase in the quantity of air passed was from 33,000 cubic feet to 37,000 cubic feet. Will you state whether those temperatures and those quantities are accurately represented in the table, and whether you think that result was due to the jet or not ?—It was due to the temperature.

4242. That temperature being the difference between 132° and 161° ?—Yes.

4243. And not as between 77° and 161°, as you formerly stated ?—I took the time of experiment as expressed, at half-past six o'clock in the morning.

4244. I am calling your attention to the temperature at the time the furnace only was in work ?—Unless you give me the time, I cannot tell to which line you are referring.

4245. Does not the temperature of 132° fix the line ?—Yes, at another hour.

4246. Is not that the time when the furnace only was employed ?—Yes.

4247. Then that is the line to which your attention is directed ?—Then I now draw your attention to the same points, and to the state of the water-gauge ; if you look at the water-gauge, you find that there is a disturbance of only 0·1.

4248. Is that inconsistent with the temperature ?—It is due to increased temperature.

4249. Is it inconsistent with the quantity of air passed ?—I cannot tell off-hand, without going into it carefully ; it requires calculation ; you are drawing my attention to the conditions under which 33,428 cubic feet per minute were produced ; before answering that, and while looking at this, you call my attention to the conditions under which 37,704 cubic feet per minute were produced ; then to the temperature line ; in one I find a difference of temperature between 132° and 161°, and in the next I find a disturbance of the water-gauge of ten-tenths.

4250. Then these being two facts stated on the table, what objection have you to raise to those facts ?—I have no objection to raise to the facts ; I take them as I find them stated ; I say the increase from 33,000 cubic feet to 37,000 cubic feet was not due to the jets, but to temperature.

4251. You say it is due to the temperature ?—I do.

4252. You first gave the temperature as the difference between 77° and 161° ; are you now satisfied that the difference should have been between 132° and 161° ? —Yes, the jet was not in action.

4253. That is your opinion ?—That is my opinion, and I think the facts support it.

4254. Mr. *Ingham.*] Have you any observations to make on the other tables ? —Yes.

Lunæ, 25° *die Julii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. Locke.
Mr. Cayley.	Mr. Baird.
Mr. Cobbett.	Mr. H. A. Bruce.
Mr. Ingham.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Goldsworthy Gurney, Esq., called in; and further Examined.

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4255. *Chairman.*] HAVE you any further observations to make upon the tables which have been delivered in by Mr. Nicholas Wood?—I presume the question applies to the tables of Mr. Nicholas Wood, in this pamphlet entitled "Experiments on the Relative Value of the Furnace and the Steam-jet, in the Ventilation of Coal Mines, communicated to the North of England Institute of Mining Engineers, on Monday, 13th December 1852, and Friday 4th February 1853." I stated, in my former evidence, that I believed, from the manner in which the experiments were made with the steam-jet by Mr. Nicholas Wood, that there was no available power produced by the jets. I do not know whether I fully explained the reasons why I came to that opinion that no available power could have been produced. I may now state, before going further into the subject, that in the experiments at Hetton 1-8th of an inch steam-jet was made to lift a 4-feet sectional column of air. It is physically impossible that a steam-jet of 1-8th of an inch and 40 lbs. pressure could lift that column to produce a force of more than 1 or 2-10ths of an inch of water gauge. That I am borne out in that opinion I think will be shown by reference to the tables in the pamphlet just referred to. In the first table, page 43, the power of the jets is not registered alone in any particular part. In the first line of figures it will be seen that the three furnaces, with the waste steam, produced a disturbance of the water gauge of 1·4, and in the second line that the three furnaces produced a disturbance of the water gauge of 1·3; without the waste, thus showing that the engine fires, together with the waste steam, by its rarefaction, made a difference only of 0·1.

4256. What is the difference of temperature in the two cases?—The temperature is 104°. I take the number of the water gauge as being the measure of power; the disturbance is 1·3 by three furnaces, the engine fires being damped down. It appears by the third line the three furnaces, and the engine fires rather low, that the disturbance was 1·1. It appears by the fourth line that, with the three furnaces in good order, the disturbance was 1·4. In the fifth line the jets were put on, but neither the water gauge, nor the quantity, is recorded. It appears by the sixth line that the jets and furnaces together produced a disturbance of 1·5. Thus it appears that only 0·1 of this amount of disturbance is due to the jet. In short, it possibly may be due to the boiler fires and the rarefying power of the waste steam after all, and not due to the jet; but, at all events, supposing it to be given as the tables state, only 0·1 can be said to be due to the jet.

4257. Mr. *Locke.*] Have you any experiments to show that the result which is given in the table is unfounded and unfair?—My experience tells me that it is impossible to produce a greater disturbance of the water-gauge than was produced under the arrangements.

4258. Then you think, in point of fact, that the statements in the table are not true?—I do not say so.

4259. What do you mean to say?—That the disturbance of the water-gauge by the steam-jet appears to be not more than 0·1 of an inch, as shown in the table.

4260. That is shown by the table?—Yes; and I want to show that the table bears out the opinion which I gave in my evidence, and the opinion which I am

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now giving, that there has been no available power produced by the steam-jet in the experiments recorded in that table.

4261. The table shows that?—I think so: if you admit it I need not go any further. I think it due to the subject, inasmuch as great mistakes have been made, to show that this power is due to rarefaction of the boiler fires, and to the waste steam, and that the jet should have fair play.

4262. Do you mean to say that the statement in the table is not true?—I mean to say, that the statement in the table bears out the opinion I have given; and I wish to support my opinion by the evidence of the table, and do not wish the Committee to take my opinion gratuitously.

4263. Then you think the statement is right?—Certainly. I would add that, according to the experiments that I have made on the steam-jet with different sized jets acting on different columns, no such power as 1·1, or even 0·3, could have been produced by the experiments in the Hetton Colliery.

4264. Do you therefore think that, if in Table 21, page 64, of Mr. Wood's book, the water-gauge is represented at 1·1, as being due to the jet, it is an error?—I do; because I do not think it was possible under the arrangement.

4265. *Chairman.*] Do you come to that conclusion because you think that the jets have been applied in an improper way, and not in such a way as to develop the whole power of the jets?—Yes. If the Committee will refer to the evidence and drawings given before the House of Lords' Committee in 1849, they will see it explained. The diagram in the South Shields Report shows the plan.

4266. Your objection to these experiments is, that although Mr. Nicholas Wood seems to have filled his pits with tubes, through which the steam-jets were working, yet that in consequence of the size of the shaft not being reduced, the steam-jet had not its proper force given to it?—Yes.

4267. Mr. *Locke.*] To what circumstance do you attribute the want of effect in the experiments which Mr. Nicholas Wood tried?—In consequence of having the column to be lifted too large for the jet; it could not lift it with sufficient power to overcome the drag of the pit; consequently the air passed back easily through the large area, and filled the partial vacuum which was formed by the mechanical power of the jet.

4268. In point of fact, do you think that the application of the jets in the shaft was so arranged by Mr. Nicholas Wood that the air, instead of being carried up, literally came down again between the jets?—Around them.

4269. Are you aware whether, in the experiments made by Mr. Nicholas Wood, the spaces between the jets were actually filled up?—Not in the first experiment. At Tyne Main cylinders were used.

4270. In the book of Mr. Nicholas Wood, from which you have quoted, you will find, in plate 1, a diagram of the cylinders which were used; and Mr. Nicholas Wood has stated in his evidence that the spaces between the tubes were filled in, so that no air could escape up or down?—Mr. Nicholas Wood, in answer to a question, stated that the sectional area apportioned to each jet at Hetton was four square feet; the diameters of the spaces were two feet; consequently, the area of column was four feet.

4271. You have formed that opinion upon a notion that the spaces between the tubes were not filled up?—They were not filled up in the experiment at the bottom of the pit at Hetton, to which these tables apply.

4272. Your observation applies to the experiment at Hetton?—Yes.

4273. Do you apply the same observation to the experiments at Tyne Main?—No.

4274. Were the spaces at Tyne Main filled up?—In the experiments at Tyne Main it is stated cylinders were used and interstices filled; the cylinders were so large, that although 0·3 to 0·4 water gauge might have been produced, more could not have been produced, acted upon as they were by jets of 3-16ths, and in some of the cylinders less; consequently, the 3-16ths of an inch jet, producing a stronger pull than the second jet, the air drew down through the cylinder, and supplied the exhaustion produced by the larger jets.

4275. That is your opinion?—Yes; that would be the case; from known pneumatic laws, and from my experiments, I think it would be so; but the minimum power was produced by the jet, as a matter of course, and that acted on the shaft below, and produced a certain quantity of ventilation; but that ventilation was very limited, the disturbance of the water gauge in those experiments

experiments could not have been, according to the experiments I have made, or according to known laws, more than 0·3; that disturbance would not overcome the drag of the pit, so as to produce any greater amount of ventilation.

4276. Do you attribute the want of success in the Tyne Main experiments to the small size of the jet, as compared with the size of the cylinder?—The same principle in a different form. The column to be lifted was not proportioned to the size of the jet.

4277. If the spaces between the cylinders had been filled in, and the jets had been properly proportioned to the size of the cylinders, do you think that a different result would have been obtained?—The interstices between the cylinders were filled in; but I apply my observation to the cylinders. The cylinder itself was so large, and the jet was so small for the pressure of steam, that the column could not be lifted.

4278. What was the size of the jet in the experiments to which you take exception?—I think there were two jets in the same pit of different sizes; consequently, one jet overpowered the other.

4279. Are you aware whether those were tried in the same cylinder?—It appears to have been so.

4280. In your opinion, what would be the proper size cylinder for a jet 3-16ths of an inch in diameter?—It depends on the drag of the pit; the power which is required to be produced, must of course be practically obtained.

4281. Have you considered what size cylinder should be employed?—For 1-8th of an inch, or 3-16ths of an inch jet, a cylinder of five inches would be sufficiently large; but the size would depend on the pressure with which the steam acted on the jets, and its free escape from its point. If the steam be doubled in pressure, then the larger cylinder would do; but at 40 lbs. to the inch, which I think is the amount which was used, it would not have produced a disturbance of 0·2 of the water gauge.

4282. Are you aware that experiments have recently been made in the north of England, to determine the maximum effect of jets of steam passing through tubes?—No. I had sent to me a paper by Mr. Longridge; on opening it, I turned to a passage which showed me that the parties had mistaken the principle, and I did not read the rest of it.

4283. In point of fact, you believed that the principle of the steam jet had been mistaken, and you did not follow out the experiments, with the view of seeing what was the maximum practical effect resulting from those experiments?—Not knowing what the experiments were, I cannot say; I have tried the jet under different pressures, and with different size cylinders. In one case, where a 3-8ths of an inch jet was used, and a 9-inch cylinder, we obtained 7,000 cubic feet per minute against a drag of three inches of water.

4284. *Chairman.*] You are now giving your evidence on the steam-jet without reference to economy?—The question of economy depends upon the conditions and circumstances in which it is placed.

4285. Is it not obvious that if you diminish the size of the cylinders, raise the pressure of the steam, and increase the area of the jets, you require more steam, and consequently must burn a greater quantity of coals?—Not so much as may be supposed. The air runs with such rapidity through a short cylinder, almost amounting to a disc, there being little or no distance for friction, that it makes up in velocity what it looses in area. In support of this opinion, I may state that a gas pipe of two inches diameter, will be well supplied by a governor through a disc of half an inch to 5-8ths of an inch. The gas goes through the disc with great rapidity; whereas through the pipes, it is dragged by friction on the sides. The same thing happens with regard to the steam-jet when it is applied either to a short cylinder or to a disc. In some cases, the steam is applied neither to a disc nor to a tube, but to a cone; and in that case very considerable power is produced; so much so, as to powerfully ventilate and condense heavy muriatic vapours, and other gaseous products. The same also has been produced in many places. The power of the jet, through a small cylinder of three inches, is applied for producing a partial exhaustion, in sugar refining. The quantity of air passing is sufficient to blow off the vapour which rose from the sugar in evaporation, and carry it away effectually, and at the same time produce an exhaustion sufficient for rapid evaporation at a low temperature. It will produce the same exhaustion as had previously been obtained by the air-

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pump; a partial vacuum only. The jet also has been used in that way, so as to produce a very strong power, proportioned to the requirements of the case, for blowing off litherage in the refinement of silver; in that case a large quantity of air passes through a very small opening; and the reason why it passes so freely is, that there is no length of sides or tubes to resist it by friction or other obstruction. So that, in the case of a coal pit, if the area of the shaft be reduced or "necked," the reduction in the amount of air will not be so great as is generally supposed. I refer the Committee to the experiments of Mr. Faraday on the steam-jet.

4286. Mr. *Locke.*] Your objections to the experiments which were made at Hetton are, that no cylinders were used, and that the air actually came down between the spaces?—Yes, it played round and round; in the other case it curled back by the sides of the cylinders.

4287. Are you aware whether cylinders were used at Killingworth?—It does not appear that cylinders were used. The steam was let down from the surface; I think the jets were placed in the naked shaft.

4288. *Chairman.*] The Committee understand you to say, that you believe more force and more power is attributed to the jet in these tables, than is actually its due, in consequence of the improper way in which the application of the steam-jet was made?—I do.

4289. That is your opinion?—It is.

4290. And the reason you have come to that conclusion is, because the diameters of the cylinders were so much greater in proportion than they ought to have been to the diameters of the steam jets, and therefore that scarcely any perceptible power was given to the steam jets?—Clearly, under the pressure of steam used.

4291. Mr. *Locke.*] What do you say would be the natural result of the steam-jet, as it was applied by Mr. Nicholas Wood?—That the air driven up in front of the jet would go round and back again by the sides, to supply the exhaustion below; forming what is called the "pneumatic flower pot."

4292. *Chairman.*] Therefore part of the air would go back again through the cylinders?—It would curl round, and go back inside the cylinders..

4293. Is there any other branch of the subject to which you desire to call the attention of the Committee?—Yes; in regard to the power which is said to have been given to the heat of the boiler fires, and the heat of the waste steam. These forces have been thought to be very considerable, and it is said that the power of the impulse of the jet is very little. That is a great mistake, as I think the tables of Mr. Wood very clearly show. I give Mr. Wood credit for the spirit in which the experiments have been conducted; and I believe his intention was to arrive at the truth. In making these extensive experiments, Mr. Wood must have had a great many persons under him, all zealous to effect a certain object; and those men in their zeal, I think, may have interfered unknown to him. In many cases, you will find, upon looking at the tables, that a larger amount of ventilation is produced by a lower level of the water-gauge. That must evidently be a mistake. In regard to the heat of the boiler fires, it will be observed, on looking at the tables, that the disturbance of the water-gauge, produced by the heat of the boiler fires and the steam, amounts to little; and the experiments show what is really due to the heat when the steam-jets are used at the bottom of the pit. Each table, upon being looked at carefully, shows that the power obtained from the boiler fires, and from the heat alone of the steam, amounted practically to little, and bears out the position that I have always taken, that except as a matter of trifling expense, it matters not whether the jets are placed at the bottom of the pit, or at the top. No doubt they are more economical at the top as far as regards expense; in the case of life and death, I do not think the difference in the consumption of coals, whether it be more or less, should be considered.

4294. You think, that with the furnaces at work, and the boiler fires, almost the whole of the quantity of air, and the disturbance of the water-gauge, would be due to the furnaces alone?—No. My observation applies to where boilers are used below, for the purpose of raising steam to supply the jets. The heat produced by the boilers and the waste steam is said to produce the power in the experiments which have been made. That this was not the case is shown by the result of the experiments made by Mr. Nicholas Wood. The word "furnace," I take to mean the furnace which is expressly used for rarefying the column; but the

the boiler fire which supplies the jets with steam does not come under the term "furnace." This is an important point settled. It certainly has not been brought out clearly before, otherwise I think the mistake would not still exist.

4295. Mr. *Locke.*] Have you studied these tables?—Since Saturday only.

4296. Have you found that the increase in temperature arising from the putting on of the jets and the boiler fires, is equal to what you expected?—The temperature produced in the up-cast shaft by the boiler fires necessary to produce the steam for the jets and the waste steam itself amounts very nearly to what I supposed, which is very considerably less than is generally believed.

4297. And it is also considerably less than the other system of ventilation by the furnace?—Of course. By furnace ventilation, the temperature must be raised high for the purpose of obtaining the buoyancy of the column; and I should observe now, as I have already observed, that the whole of the air which passes through the pit and up the shaft, must be raised to that temperature, whatever it may be; so that if the quantity of air coming through the pit is double, the quantity of heat must be doubled to bring it up to the temperature. There is a limit to the quantity and power of ventilation on that account. It does not go on *ad infinitum*. The steam-jet, on the contrary, runs nearly to a vacuum; but the furnace, from the physical construction and condition of the pit, must be limited both to the quantity of heat it can give out, and the quantity of air it can heat.

4298. *Chairman.*] When you obtained that limit, it would be necessary to limit the heat and ventilation of one furnace, either to put up another furnace, or if it was not sufficient, to sink another pit, and put a furnace into another pit? By another pit you may reduce the drag of the pit, by passing the air through shorter passages; and so you would effect, by the power of another pit and another furnace possibly, all the ventilation you required; if the requirements of the pit is more than you could get by the furnace, some other means must be had recourse to.

4299. Is there anything else you would wish to state?—I wish to say a few words with regard to a self-registering anemometer. It is said to be practically difficult, if not impossible, to prevent the interference of any person who might be disposed to tamper with it.

4300. You are of opinion that an anemometer might be placed out of the reach of persons, so that it could not be tampered with?—It might be so placed as to be out of the reach of all parties, except those who had locks and keys to get at it. The means of doing it, I think, are very simple.

4301. Describe the means you would suggest in order to effect that object?—The mode of effecting it would be, to cut a special passage from the spot in which the anemometer register was fixed, round from a point taken before the anemometer, and terminating beyond the anemometer; and let the area of that passage be the same as the area of the gallery, so that, by stopping the direct course, the whole of the air would go round the loop that short distance. The entrance into that loop might be railed off by iron grating, and locked; so that no one could get in except the inspector, or a person deputed to open it. When the direct door was shut the whole of the air must go through the loop on the anemometer and when the direct door was open of course it would go directly through, and the anemometer would not be affected; it would be the interest of all the people in the pit to have the anemometer at work; they would take great care whenever they passed to shut the door, placed in the direct passage between the loop ends, after them. The air would then pass through this special passage, which could not be interfered with. An anemometer placed there, I think, would be perfectly safe from interference in any way.

4302. It would show the amount of air passing in the particular spot where it was placed, but it would not show the amount of ventilation at the faces of the bords where the men were working?—No. If it was necessary to do that, the same plan might be adopted; but I am supposing that the register anemometer, which the Committee of 1852 thought desirable, to be placed in the extreme workings.

4303. Would it be possible to cut such a passage as you have alluded to round the bords?—They would be necessary only in the permanent air-courses.

4304. Your opinion is, that it is necessary to rely on the skill and experience of the overman in addition to the anemometer, and not to rely simply on the anemometer as a test?—I should only rely on the anemometer as a test in the great

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air-courses. All the splits and divisions must depend on the air going through the great workings. The quantity of air going into a pit, and the quantity going out of the pit, might be measured by an anemometer so placed, without the possible interference of any designing person; one placed at the extreme working would show what portion was carried round the extreme working.

4305. Its distribution through the mine must depend on the skill of the overman?—Yes; but by an anemometer so placed, you obtain the proportion going round the extreme workings; and if a certain quantity passed the extreme workings, taken with the others, would be a measure of the amount of ventilation going on.

4306. Is there anything else you wish to state?—I may, perhaps, be allowed to state, that it has been stated in evidence before this Committee that I was invited, with Mr. Forster, to witness the experiments made by Mr. Wood, and therefore somewhat responsible. The understanding in the Committee of 1852 was, that if Mr. Wood made experiments, I should be invited to superintend their arrangement, and see that they were made fairly and properly. I received no invitation whatever from Mr. Wood for this purpose; I received from a stranger a lithograph circular, stating that certain experiments were to be made, and that my company was earnestly requested, or something to that effect. I answered it by saying that I could not attend at that time; I did not see the use of attending to witness experiments, after they had been got up by another person, on which I had not been consulted. The spirit of the engagement was, that I should be invited to superintend and adjust the experiments with Mr. Forster.

4307. Mr. *Locke*.] Of what "engagement" are you speaking?—I should rather say invitation.

4308. Of what "invitation" are you speaking?—The engagement of Mr. Wood, in the Committee of 1852, to invite me to the experiments that he was about to make.

4309. Did Mr. Wood invite you or not?—He did not.

4310. You received a circular; did you know whether it came from him?—The circular was signed by a stranger; whether it came from Mr. Wood or no I did not know.

4311. Mr. Wood has stated before this Committee that you received a circular, which probably was lithographed, and similar to those which were sent to other parties?—That was after the experiments were made. I complain that I was not invited to superintend the experiments, or to see that they were fairly made.

4312. Would not Mr. Wood, in conducting a series of experiments, wish to conduct them himself?—The understanding in 1852 was, that Mr. Forster and myself were to be invited. There was a promise, on the part of Mr. Wood, that he would invite me and Mr. Forster to superintend and assist the making of the experiments.

4313. How was that promise given?—In words, by Mr. Wood. The same occurred in the House of Lords.

4314. *Chairman*.] Is it in Mr. Nicholas Wood's evidence before the Committee of 1852, that you find this engagement?—Yes; my impression is that it is there stated.

4315. In Question 1312, Mr. Wood is asked, "You are now very busy on the subject of these experiments; with regard to the jet, when it is ready for examination, it is your intention, I understand you to say, to invite Mr. Forster and Mr. Gurney to see it, and you will have it fairly tested?" The answer is, "My object is to have it properly and impartially tested; there is a great doubt hanging over it, and I consider that it ought to be set at rest"?—I consider that the spirit of what is implied there is, that I should see that the jets were properly arranged.

4316. You say that you had a lithographed letter from a stranger; did you know, when you received that lithographed letter that it came from Mr. Nicholas Wood?—No; I received this lithographed letter at a time when I was very busy; I saw it was a circular invitation from Durham; I desired my young man to answer it, and say that I could not attend.

4317. Did you or not know that the lithographed letter came from Mr. Nicholas Wood, although it was signed by a person with whose name you were not acquainted?—My impression was, that it was not Mr. Nicholas Wood's invitation

4318. Mr. *Locke.*] The letter purported to be an invitation to you to be present at some experiments to be conducted by Mr. Nicholas Wood?—It seemed a circular letter of invitation.

4319. The letter invited you to witness some experiments to be conducted by Mr. Nicholas Wood?—Yes, to the best of my recollection.

4320. Mr. *Ingham.*] The answer which you sent, declining to attend, did not allege as your reason that you were not satisfied that the letter came from Mr. Nicholas Wood, but that you were much engaged?—I considered that every letter required an answer, and my answer to that letter was, that I could not attend. I could not see the use of going 400 miles to see a set of experiments, which I knew from private information from other quarters, were of no value.

4321. It was not from any doubt whether or not the invitation came from Mr. Wood?—It did not enter into my consideration. Possibly, I might have thought that the invitation should have come personally from Mr. Wood, if he had wished me to be present. I certainly was not invited by Mr. Wood to superintend the experiments, or to see that they were properly made, and am therefore in no way accountable for them.

4322. *Chairman.*] You received private information that the experiments would not be conducted in a way which you thought would bring out the full power of the steam-jet, and therefore you declined to be present?—I felt no interest in it; I had no motive in putting myself to the inconvenience and expense of going 400 miles; my time is of value to me.

4323. Mr. *Cayley.*] Have you anything to correct in reference to your evidence given at the last meeting of the Committee, with regard to the effect of the steam-jet fixed at the upper end of the down-cast, in case of an explosion?—Yes; I neglected to state that the great advantage of the application of the steam-jet at the top of the down-cast, in case of an explosion, would be to enable men to follow the fresh air driven down, and to restore the stoppings as they went along, so that the air might be driven round to displace the after-damp which may have been collected in other parts of the pit. The stoppings in case of explosion, I stated, were generally blown away; and if the steam-jet, the furnace, or any other ventilating power, was applied to the up-cast, the air would run the short course from the down-cast to the up-cast, without going through the workings to where the mischief existed. I stated, that if a steam-jet was applied to the down-cast, and made to force the air in, it would drive the air down the down-cast, and it would pass direct into the up-cast. I neglected to state, that men might, with safety follow the fresh current, and restore the stoppings, and by that means drive fresh air round the workings, expel the after or choke damp, and, arrive in time to save life.

4324. Will you explain the difference between high and low pressure steam, with regard to the rate at which they severally move the jet?—There is a great mistake existing which has appeared in evidence on that point; whether steam be four or five atmospheres, or whether it be water, provided it be a given quantity, say a cubic foot, and has to pass out in a given time, through a given size cylinder or pipe, it would go at the same rate; but if high elastic steam, namely, steam of high pressure, when it came nearer the end of the cylinder or pipe, it would expand, and go on with an increasing velocity, and escape into the air, at a far greater rate than if it was low pressure; consequently the escape of the steam into the air, which produces the jet, is far greater from high pressure than from low pressure; but the rate at which the steam passes through the feed-pipe is the same.

4325. Will you explain how the principle of the steam-jet is connected with the laws of motion?—The action of the steam-jet is founded on the first law of motion, namely, that bodies in motion go on for ever, unless they are stopped by something. The air is set in motion by the steam-jet, and it would go on under this law at the same rate until it was stopped by some opposing force. The only opposing force when it is so started, it meets with, is the surrounding atmosphere at rest; the surrounding atmosphere is set in motion, it receives a portion of its momentum and falls into the stream; this stream like the first, continues to meet with air at rest, to set it in motion, and so on, until the first force is stopped or balanced. By this means the full motive power of the steam is obtained; if properly applied, there can be no doubt it is the most simple and the most perfect mechanical power for producing ventilation. If improperly applied,

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as I have stated in a previous part of my evidence, for certain purposes, it would fail under this imperfection, but not under the laws of its motion.

4326. Is the steam jet now applied to boats as well as locomotives?—The steam jet is applied to almost every steam boat on the river. It was first applied, as stated in evidence in the Lords, on the Garonne, in France, to increase the power of the steam-engine to stem the torrent. It has only been so applied generally here within the last few years. It is applied to the boat of the river, as a means of competition between different rival boats, for the purpose of gaining speed, obtaining quick fire, and other advantages. It is being extended, I believe, to the navy. It has been introduced in four French war steam vessels, and I have no doubt will shortly be introduced in ours.

4327. You have stated that a high disturbance of the water gauge has been practically obtained. Have you anything further to state on that point?—I have stated, in my former evidence, a case which may be considered frivolous, namely, that of cupping; it was to show the height of mercury; as the word "practically" was somewhat misunderstood, I should explain that it has been applied for the purpose of refining silver, and for the purpose of forming the Salts of Crome, to the blast furnaces and various other purposes; the power has been got up in these cases, to about eight or ten inches of the water gauge.

4328. Have you any further opinion to give on the subject of the safety lamp?—My opinion of the safety lamp has not been changed. I have the same opinion now that I had in 1835.

4329. *Chairman.*] Are you practically acquainted with the safety lamp in coal mines?—I am not practically acquainted with coal mines so far.

4330. Have you ever entered into any series of experiments with safety lamps from the gas generated in coal mines?—I have.

4331. In a coal mine?—Not in the mine, but with gas taken out of a mine, which I have taken out myself. I should observe, in answer to that question, that it has been lately found that the fire-damp in coal-pits often contains olifiant or bi-carburetted hydrogen gas, and that olifiant or bi-carburetted hydrogen gas is more inflammable than the common carburetted hydrogen gas; it is possible, practically, the safety lamp may be less safe on that account. The experiments which I heard described by Mr. Wood, do not apply to the working condition of a pit. The current which he used was a uniformly increasing current, whereas it is found the sudden change of the current, that found in an eddy, which produces the greatest danger.

4332. Mr. Wood distinctly stated that he could not get up a heat sufficient to explode the lamp under any circumstances, except by gradually increasing the current?—If he had jerked, or changed the current, it would have exploded. It explodes at four feet rate of current, at a red heat. The known conditions under which the lamp explodes are not new. They have been repeated over and over again by the first men of the age, before 1835 up to the present time. In the evidence of 1835, at least 20 scientific men, including Dr. Birkbeck, Dr. Murray, and Dr. Pereira, and others, went through the experiments and showed them to the Committee.

4333. Where?—At the University.

4334. Not in a coal mine?—No; they were better made than they could have been in a coal mine.

4335. Mr. *Locke.*] Are you aware that it has been alleged, since these experiments were made, that the Davy lamp is unsafe?—Yes; I am aware of it from the evidence of 1852, and also from the reports that I have seen.

4336. Have you any opinion to give as to the security or otherwise of the Davy lamp?—I think that the lamp is perfectly secure in a still atmosphere, and that it is perfectly secure in motion when the fire-damp has not arrived at the most inflammable point, and the wire gauze to a red heat, but that it is not safe when the fire-damp has arrived at the explosive mixture, or four to one.

4337. Have you read the evidence of Mr. Wood on that subject?—I heard his evidence.

4338. Are you of opinion that it is a safe lamp to be used under the circumstances, and within the limits recommended by Mr. Wood?—No; I think the experiments of Mr. Wood were made under a uniformly increasing current, never found in a coal pit, whereas the great danger is from the retrograde. It was by the retrograde that the lamp exploded in the hands of Sir Humphry Davy.

Davy. It was also under those circumstances and conditions that it exploded at the Westminster Gas Works; and I think there is evidence in 1835, 1849, and 1852, to show that it must have exploded under those circumstances in coal-pits. *G. Gurney*, Esq. 25 July 1853.

4339. *Chairman.*] Did you hear Mr. Wood state that a series of experiments had been made by Mr. Johnson, by moving the lamp backward and forward, and so performing the retrograde movement to which you allude?—I did not.

4340. If Mr. Wood so stated, and that under no circumstances the lamp would explode with retrograde motion, would it alter your opinion?—No; because I have seen it done, and I would rather believe what I see than what I hear. You are treading on dangerous ground.

4341. If Mr. Wood stated that this gentleman instituted a series of experiments, moving the lamp backward and forward, and performing the retrograde motion, which you state is the motion from which the danger accrues, and that under no circumstances whatever could he get any of the lamps to explode, that would not alter your opinion?—Not the slightest; I have made more experiments on this subject, perhaps, than any man living, and because I have seen the experiment repeated by three or four different parties; when one person succeeded another did not.

4342. Did you ever see experiments of that kind made in a mine?—No; and I think no man would dare to try such experiments in a mine.

Thomas Emerson Forster, Esq., called in; and Examined.

4343. *Chairman.*] YOU are Viewer and Manager of Coal Mines?—I am. *T. E. Forster*, Esq.

4344. You are very extensively employed?—I am.

4345. With the exception of Mr. Nicholas Wood, you are more extensively employed than any other person in the profession?—Probably I may be.

4346. You are extensively employed in the counties of Durham and Northumberland?—Yes.

4347. You have had great experience in the direction of colliery operations?—Yes.

4348. Has your attention been particularly called to the ventilation of mines?—Yes.

4349. What is your opinion as to ventilation by furnace and steam-jet?—I have both systems employed at my collieries. At Seaton Delaval, the steam-jet is employed.

4350. In how many pits have you employed the furnace, and in how many pits have you employed the steam-jet?—I have only employed the steam-jet in Seaton Delaval Colliery.

4351. In how many collieries have you employed the furnace?—Six.

4352. To which do you give the preference in ventilation?—At Seaton Dalaval I like the steam-jet.

4353. Why do you prefer the steam-jet at Seaton Delaval, and not use it at other pits?—Because at Seaton Delaval I had an engine placed under ground, to which I could easily attach the steam-jet, whereas at some of the other collieries I have not.

4354. Did you ever ventilate Seaton Delaval Colliery by the furnace?—Yes.

4355. Did you find that you could not obtain sufficient ventilation to supply the requirements of the pit by the furnace?—With two furnaces I only got 53,000 cubic feet per minute; whilst according to the last measurement, on the 18th of May, the steam-jet, which I employ at present, was 88,363 cubic feet per minute.

4356. In ventilation with the furnaces, how many up-casts had you?—I had two up casts at that time, whereas with the steam-jet I have only one at present.

4357. How many down-casts?—Four.

4358. Of what size are your furnaces?—The furnaces I think were eight or nine feet furnaces.

4359. What length?—Six feet.

4360. What is the amount of ventilation by the furnaces?—Fifty-three thousand cubic feet per minute.

4361. Is that the highest amount of ventilation which ever was gained by the furnace in a particular pit?—That is the highest amount of ventilation I could get at Seaton Delaval Colliery.

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4362. Can you state why you could not obtain a higher amount of ventilation by the furnace at Seaton Delaval?—I do not know; there were two furnaces and two up-casts. After I had seen the experiments at the Polytechnic that year with the steam-jet, I thought it was desirable to place it at Seaton Delaval, where I could do it at comparatively a trifling expense; I did so; and I get this large amount of ventilation.

4363. In any other of your collieries, have you a larger amount of ventilation passing by the furnace, than you obtained at Seaton Delaval?—Yes.

4364. Therefore there is something in the Seaton Delaval pit which prevented the application of the furnace being successful?—The other pits to which I allude, as having a greater amount of ventilation by the furnace, are differently circumstanced altogether; there is a much larger up-cast shaft.

4365. What is the size of the up-cast shaft at Seaton Delaval?—Eight feet.

4366. If you had increased the size of the up-cast shaft in Seaton Delaval Colliery, do you think you would have obtained a greater amount of ventilation?—Probably I might have got more ventilation by the furnace.

4367. Would that have been attended with great risk and expense?—Yes.

4368. In consequence of difficulty from water breaking into the pit?—No; we have no tubbing in at Seaton Delaval.

4369. What was the state of the ventilation at Seaton Delaval Colliery, when you ventilated by furnaces alone?—It was not sufficient to clear the mine of gas.

4370. Were your collieries not in a safe state?—I did not consider them to be in a safe state.

4371. Had you any accidents?—I think we had none, with the exception of a man getting burnt; but I was working with a safety lamp in an explosive mixture, which I did not like at all.

4372. A mixture in which you would not have dared to work with a naked light?—By no means.

4373. How long have you had the steam-jet in operation?—Since December 1848.

4374. In your evidence before the Committee of 1852, you stated that you had had the steam-jet in operation four or five years; have you applied more jets since that time, or do you still continue the same form of steam-jet as you then had?—I have a few more now than I had at that time.

4375. You stated in your evidence of 1852, that you had applied 25 jets?—Yes.

4376. How many jets have you now applied?—Thirty-three.

4377. Are the diameters the same as those to which you alluded in 1852?—They are 3-16ths of an inch.

4378. Were they 3-16ths of an inch in 1852?—No; I think not quite; they failed, and I was obliged to get new ones.

4379. Is every other condition of the pit similar to what it was in 1852, except that you have increased the number of jets?—Except that the workings have extended much further.

4380. Have they extended greatly?—There have been 12 months' working, and we take out 200,000 tons each year.

4381. What is the thickness of your seam?—About five feet.

4382. Over how many acres does it extend?—I fancy we take out about 40 acres in a year.

4383. Consequently you would have a greater number of goaves?—Yes.

4384. How far on from the shaft have you got?—We are spreading in all directions. Perhaps the most northern part of the colliery has not gone further than it was last year, but we have gone further east and west.

4385. Is east and west the level course?—No.

4386. Mr. *Locke*.] Can you state the aggregate length of the airways?—At Seaton Delaval, 14 miles.

4387. *Chairman*.] In your evidence in 1852, you stated that you obtained by the steam-jet 85,000 cubic feet of air per minute?—Yes; and I am now getting nearly 90,000.

4388. In consequence of increasing the number of jets from 25 to 33?—Yes.

4389. Mr. *Cayley*.] Is there any material increase in the cost?—No.

4390. Mr. *Locke*.] You burn more coal?—The engine is obliged to be there, whether the jets are on or not.

4391. *Chairman*.]

4391. *Chairman.*] Is the steam which is used in the jets that which has been used by the working of the engine?—No; it goes direct from the boiler to the jets.

4392. If you use steam separately for the jets, must you not burn more coal to produce that steam?—Yes; there must be more coal used to raise that steam.

4393. And therefore, of course, there is some increase of cost?—Yes.

4394. In a coal pit you do not take coals as being of great value, and you give your evidence with reference to the value put on coal at the bottom of a pit?—We burn nothing but small coal.

4395. You do not consider small coal of any value?—It is of value, certainly; but not of so much value as the round coal.

4396. You stated in 1852 that you had had no explosion or accident since the establishment of the steam-jet; since that period have you had any explosion or accident?—None.

4397. Is Seaton Delaval Colliery in a satisfactory state as regards ventilation?—Perfectly.

4398. Can you institute a comparison of the ventilation between Seaton Delaval Colliery and any of the collieries in the neighbourhood of a similar extent?—Yes; I should like to compare Seaton Delaval Colliery with Mr. Wood's colliery at Killingworth.

4399. Are they of the same extent?—I should think the Seaton Delaval Colliery is of greater extent than Killingworth; they are about four miles and a half apart, and perhaps Mr. Wood's seam is a foot thicker.

4400. What is the depth of each from the surface?—Seaton Delaval is 106 fathoms, and I think Killingworth is 175 or 180 fathoms.

4401. There would therefore be more gas in all probability in Killingworth than in Seaton Delaval?—Yes; but I am not comparing it as to the gas, but as to the quantity of air.

4402. Mr. *Locke.*] The quantity of air which is drawn through Killingworth Colliery is not so great as the quantity which is drawn through Seaton Delaval Colliery?—No; they have the furnace with a ventilation of 33,000 cubic feet per minute; and I have the steam-jet at Seaton Delaval with a ventilation of 88,000, or 90,000 cubic feet per minute. That shows that my mode of ventilation at Seaton Delaval is superior to Mr. Wood's at Killingworth, with the furnace, inasmuch as I have 88,000 or 90,000 cubic feet per minute, which is more extensive than that which Mr. Wood obtains at Killingworth, with his furnaces, where he only gets about 33,000 cubic feet per minute.

4403. *Chairman.*] At Great Hetton, is not the quantity of air passing through the mine nearly 210,000 cubic feet per minute?—Yes.

4404. Do you attribute the greater amount of air passing through Seaton Delaval than that which passes through Killingworth, entirely to the operation of the steam-jets?—I do not know that I would; I think probably that something may be due to the size of the air passages.

4405. Then you do not draw the attention of the Committee to this comparison, in order to illustrate the superior power of the steam-jet?—I think that Mr. Wood, with his furnaces, ought to have as large a ventilation at Killingworth as I have at Seaton Delaval.

4406. Mr. *Locke.*] Does the depth of the shafts, in your judgment, make a difference?—The greater the depth of the shafts, the greater will be the ventilating power.

4407. Do you think that Mr. Wood, by his mode of ventilation, ought to have passed more air through Killingworth than you passed through Seaton Delaval?—Yes.

4408. You obtained 53,000 cubic feet?—Yes, by the furnace; but now I obtain nearly 90,000 cubic feet per minute by the steam-jet.

4409. Do you recollect the depth of the Hetton Mine?—The Hetton old pit is about 150 fathoms.

4410. That is a medium depth between Hetton and Seaton Delaval?—Yes.

4411. Do you know how many furnaces Mr. Wood uses at Killingworth?—One, I believe, but I am not sure.

4412. Do you know what number he employs at Hetton?—Three.

4413. Do you suppose, that if he employed three furnaces at Killingworth, he would obtain an increase of ventilating power?—Probably he might; but

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while he has three furnaces at Hetton, I do not consider that his ventilation is good at the extremities.

4414. You say it is 200,000 cubic feet per minute?—Yes; still that does not show that his pit is in a good state; and I say it is not.

4415. In your judgment, would the application of the same furnaces at Killingworth which Mr. Wood has employed at Hetton have increased his ventilating power?—I fancy that they would.

4416. At Seaton Delaval you obtained 53,000 cubic feet of air per minute by your two furnaces?—Yes.

4417. Did you ever apply three furnaces?—No.

4418. In your opinion, what would have been the effect of employing three furnaces?—I think that in all probability I might have obtained an increased quantity.

4419. What quantity do you suppose you might have got by another furnace?—I cannot tell; perhaps 10,000 or 15,000 cubic feet per minute.

4420. You say that you had two up-cast shafts at Seaton Delaval?—I had at that time.

4421. Did you employ both your furnaces at one shaft?—No.

4422. At Killingworth there is only one up-cast?—There is a very large up-cast shaft.

4423. At Seaton Delaval, is there a large up-cast?—No; it is only eight feet.

4424. What was the object of doing away with your second up-cast?—Because the steam-engine was used at the bottom of the other up-cast; I could not apply the steam-jets in the other from that boiler.

4425. Did you close up the other up-cast entirely?—Yes.

4426. At Seaton Delaval are the jets placed at the bottom of the pit or at the top?—At the bottom.

4427. You have 33 jets?—Yes.

4428. They are 3-16ths of an inch in diameter?—Yes.

4429. Are they placed in cylinders?—No.

4430. They are in an open shaft?—Yes.

4431. Has the air in the steam-jet free access to pass between them?—Yes.

4432. Do you think that is an advantageous mode of applying the steam-jet?—No; I think that if there were cylinders they would be much better; and I do not think we have arrived at the true mode of applying the jets correctly.

4433. Have you any apprehension that the air passes down the pit instead of going up?—It could not, at the bottom of the pit. If the jets had been placed at the top of the pit, it would have done so, because I have tried it.

4434. Have you tried it with the same arrangement of the jets?—Yes; and I have also tried it at the top of the pit with cylinders; and when any of the jets did not act, the air descended immediately down the cylinder.

4435. What is the space between your jets, as they are arranged in your present workings?—Eight feet in diameter; and there are 33 jets.

4436. Eight of your jets, taking the outer circle of the shaft, must be nearly three feet asunder?—Yes.

4437. You have no apprehension that any air passes down between those jets?—It could not, at the bottom of the pit.

4438. You think that without cylinders, or anything else, this is as good a mode of applying the steam-jet as any that you have seen?—I do not think that we have arrived at the true mode of applying the jets. My opinion is, that if cylinders were placed on the jets, it would be still better.

4439. Are you aware that Mr. Wood, in his recent experiments, employed cylinders?—No; I have not read his book.

4440. Have you heard that he tried cylinders at Hetton?—No; I cannot state that of my own knowledge.

4441. At all events, you are satisfied with the practice you have acquired during the last four years; and although you may not think it is the very best mode which may hereafter be adopted, yet it is the best mode you know at present of applying it?—Yes.

4442. You say you have 14 miles of air courses; do you recollect what is your water gauge at Seaton Delaval?—One inch and a half, which is equal to 8 lbs. per square foot.

4443. Do you generally work at one inch and a half water gauge at Seaton Delaval?—Yes.

4444. Have you the means of trying that experiment during several times in the day?—You may try it the whole day, because the water gauge might remain in the separation door between the down cast air and the return air.

4445. Is the one inch and a half water gauge the result of one observation, or of many observations?—It was in the door during the time I was making those experiments, and it never altered.

4446. What experiments are you alluding to?—I mean on the day that I measured the air, namely, the 18th of May.

4447. Have you got those experiments in a tabulated form, which you can hand in?—Yes. (*The Witness delivered in the same.*)

Vide Appendix.

4448. *Chairman.*] The amount of air that you have spoken of, namely, 88,000 cubic feet, is due to the jets and the rarefaction of the boiler fires?—No doubt of it.

4449. Is there any gas apparatus in your pit?—Yes; but I think there was only one retort on the day the experiment was tried.

4450. That would add to the heat?—Yes.

4451. Have you instituted any experiments in Seaton Delaval Colliery, with the steam-jet, without the aid of the rarefaction caused by the boiler fires?—I could not do that, because the engine is constantly at work.

4452. Mr. *Locke.*] Did you ever try the contrary, namely, by keeping the fires burning and not issuing the steam-jets?—Yes.

4453. What did you get by that?—Considerably less.

4454. Mr. *H. A. Bruce.*] Less than you got by the furnaces?—No.

4455. Mr. *Locke.*] Do you still get as much by your boiler fires as you originally obtained by your two furnaces?—Yes; but I cannot speak correctly to it.

4456. Does not that go to show that there is considerable effect from the boiler fires?—There is no question of it.

4457. Are they large boiler fires?—No.

4458. What is the size of the boilers?—Two of them are 26 feet long by six feet in diameter, and two of them are 30 feet long by five feet in diameter; and three of those boilers are daily at work, loaded 35lbs. to the inch.

4459. What is the work the engine has to do?—The engine has to draw about 900 tons per day, along a plane 2,200 yards long.

4460. Is it inclined?—There are only 12 feet difference between the shaft and the extremity.

4461. The boilers would not require to be of that size, except for ventilating purposes?—I should not like to depend on less boilers than three for the working of the engine, because if anything occurred to a boiler the work would be entirely stopped, the great bulk of the colliery work coming from that direction.

4462. *Chairman.*] Is it a high-pressure engine?—Yes.

4463. Does the whole of the exhausted steam go up the pit?—Yes.

4464. Mr. *Locke.*] So that, in point of fact, you have one boiler extra only for the steam-jet?—Yes.

4465. Mr. *Cayley.*] Were these boiler fires as well adapted for ventilating purposes as the original furnaces which you had there?—No; when they were erected they were not intended for ventilating power.

4466. Have you reason to believe that you have the same ventilating power as you obtained from the furnaces?—I think a long way on.

4467. Of the 90,000 and odd cubic feet of air per minute, which you now obtain, how much do you attribute to the steam-jet, and how much do you attribute to the boiler fires?—

4468. You have stated that 53,000 cubic feet of air per minute was the utmost you could obtain by means of the furnaces?—Yes.

4469. Were your air-courses good?—Yes.

4470. Are they better now than they were before?—I think they are much about the same. They may be, perhaps, a little more now.

4471. If you applied more jets to the Seaton Delaval shafts, do you consider you could increase the 90,000 cubic feet with your new jets?—Yes; I believe that if the number of jets were increased, we should get a greater quantity of air.

4472. What limit would attach to the increase that you could get by increasing the number of jets?—That I cannot state.

4473. What makes you fancy that you do not now apply the jet in the best manner?—

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manner?—My opinion is that, as I stated before, if the jets were placed in cylinders, we should get a greater power.

4474. Does the effect depend on the mode in which the jets are applied to the cylinders, or upon the striking distances?—Yes.

4475. Do you think that the jets might be so applied, even when cylinders were used, that there might be a loss of power?—Yes; but I think that by the cylinders we should get an increased power.

4476. Have you ever consulted Mr. Gurney upon the best mode of using the steam-jet?—Yes.

4477. Do you consider Mr. Gurney a good authority?—Yes. The use of cylinders was Mr. Gurney's suggestion. I believe they have been applied at some alkali works at Shields, where, I have been told, an immense quantity of air has been obtained.

4478. Do you allude to some alkali works which were a great nuisance from an offensive smell?—Yes; but I am not sufficiently acquainted with the subject to give any information upon it. I have had an invitation from Mr. Bell, of South Shields, to go down and see it, and he says that he is quite satisfied, that if we applied the jets in the way they are applied at his alkali works, we should get four or five times the power which we now obtain.

4479. Mr. *Ingham.*] You allude to Mr. Bell, at the Don Alkali Works?—Yes.

4480. Mr. *Cayley.*] Having got this increased ventilation by means of the jet, at Seaton Delaval Mine, why did you not apply it to other mines?—Because all the other mines, with the exception of South Hetton, do not require any more ventilation than they have.

4481. Are the shafts deep?—Not very deep, but the quantity of gas is not very great; for instance, at Netherton there is nothing but carbonic acid gas.

4482. Is Seaton Delaval your most fiery mine?—Yes; it makes a great deal of gas.

4483. If the Seaton Delaval shaft was as large as that of Hetton, what amount of ventilation could you get by the steam-jet, as at present applied?—I should think we might very easily double it.

4484. Do you know the Hetton Pits?—Yes; and I know also that the Hetton Company are about to sink another pit, because they are not satisfied with the ventilation in one of their pits which is worked by furnaces.

4485. Notwithstanding the evidence that Mr. Wood has given as to the satisfactory state of the ventilation in the Hetton Pits, the proprietors are not satisfied?—It was Mr. Wood's own suggestion that another pit should be sunk.

4486. Did Mr. Wood try any experiments at Seaton Delaval mine?—No.

4487. Mr. *Ingham.*] Do you know the cause of the pit being sunk at Hetton?—Yes.

4488. *Chairman.*] Do you know, of your own knowledge, that Mr. Wood has recommended the sinking of another shaft at Hetton, in consequence of the ventilation being defective?—Yes; because I represent the Hon. Mrs. Cochrane, one of the owners of the colliery; and I am one of the committee to manage the colliery.

4489. Mr. *Cayley.*] Is one inch and a half all the effect that you have ever produced on the water gauge by the steam-jet?—Yes, at Seaton Delaval.

4490. Do you believe that you could increase that effect?—The air passages are pretty clear, or else we should probably raise it more; the greater the drag, the higher the water gauge would go.

4491. Mr. *Locke.*] Is not the 88,363 cubic feet of air per minute, taken through Seaton Delaval Colliery, derived from two or three sources, namely, that which is brought along the engine plane, and that which is brought along the Victoria drift?—Yes.

4492. Is there also a quantity of 17,250 cubic feet for boiler fires?—Yes.

4493. What does that mean?—That feeds the boiler fires.

4494. Where was it estimated?—It was measured between the bottom of the down-cast, and where it goes to the engine fires.

4495. There are three drifts?—The up-cast pit, where the engine is placed, is about 60 yards from the down cast shaft; and it was measured between the down-cast shaft and the doors leading to the boiler fires.

4496. Then, in point of fact, that which is taken from the boiler fires has gone directly from the down-cast to the up-cast?—Yes. It does not go into the workings at all. That is the quantity which is going down the down-cast pits.

4497. And

4497. And therefore, the quantity of air going through the mine by the engine plane and the Victoria drift would be about 70,000 feet?—Yes. *T. E. Forster*, Esq.

4498. You have stated that Hetton Colliery was not in a satisfactory state of ventilation; does the satisfactory state of the ventilation of a pit depend on the quantity of air passing down the pit?—No. If it is not carried to the extreme of the workings, the pit cannot be well ventilated. 25 July 1853.

4499. Mr. *Cayley*.] Do you think that Mr. Wood does not know how to distribute the air when he gets it?—I think he knows that very well.

Martis, 26° *die Julii*, 1853.

MEMBERS PRESENT.

Mr. Hutchins.	Mr. H. A. Bruce.
Mr. Ingham.	Mr. Cobbett.
Mr. Cayley.	Mr. Locke.
Mr. Mostyn.	

EDWARD J. HUTCHINS, Esq., IN THE CHAIR.

Thomas Emerson Forster, Esq., called in; and further Examined.

4500. *Chairman*.] YOU stated yesterday, that you had not read Mr. Nicholas Wood's pamphlet?—No. *T. E. Forster*, Esq.

4501. You have heard of the experiments of Mr. Nicholas Wood?—Yes. 26 July 1853.

4502. Have you any doubt that those experiments were conducted by Mr. Nicholas Wood, to the best of his judgment, to arrive at the most satisfactory results that could be obtained, and to give himself a fair knowledge of the best system of ventilation?—I have no doubt that he took every pains for that purpose, and we are much indebted to him for the great labour he has bestowed upon the subject.

4503. Whether the steam-jet is the best system of ventilation, or whether the furnace is the best mode of ventilation, have all these experiments and inquiries done great good, as tending to improve ventilation generally in collieries in the north of England?—I have no doubt they will do a great deal of good.

4504. Mr. *Locke*.] It appears by the paper which you delivered in yesterday, wherein you put down 88,363 feet of air as being carried through Seaton Delaval mine, that 17,250 feet of the 88,363 feet pass directly from the downcast shaft to the boiler fires?—No doubt of it.

4505. Then that quantity, in point of fact, performs no service in the ventilation of the mine?—Except feeding the boiler fires.

4506. And, in point of fact, instead of 88,363 feet passing through the mine, there are only 71,000 feet passing through the mine, beneficially speaking?—Exactly so.

4507. Do you think it is an advantage to take the air which supplies the boiler fires directly from the downcast shaft, without letting it intermix with the impure gas of the mine?—Yes; we could not raise the steam with the return air.

4508. When you had the furnace at the mine wherein you produced 53,000 feet, as you stated yesterday, did you use the pure air along the drift, or did you take it from the mine?—The return air went over the furnace at that time.

4509. Then, in point of fact, you never instituted a comparison in reference to the furnace and the jet, by using the pure air in the one case as well as in the other?—Never; but my opinion is, that even with the furnace, if the first of the air was applied to the furnace, and the return air went into the shaft without going over the furnace, a greater quantity of air would be obtained through the workings of the mine.

4510. Then you think there is an advantage in keeping the impure air of the mine away from the boiler fires for the use of the steam-jet, and from the furnaces, for the purpose of raising the ventilation by that means?—Yes, for two reasons: first, there is a greater pressure on the fires, and consequently the fires would burn better; and, secondly, in case of the pit getting foul, if the furnaces were fed by the fresh air, no accident could happen.

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4511. Do you think it is better to give up that proportion of air which the fires consume, in order to obtain the greater advantage of having more oxygen in the air to begin with, to escape the danger arising from the chance of accident?—Yes; but I believe that a greater quantity of air would be obtained down the pit.

4512. You think that the free combustion would compensate for any loss of that kind?—Yes.

4513. It appears from a calculation that you have made in the paper that you have delivered in, that you consider that the heat arising from the fires under your boilers is the same amount as the steam-jet?—Nearly so.

4514. The effect, according to your opinion, of the heat producing the ventilation in Seaton Delaval colliery, was in the proportion of about 51¾ per cent., while the mechanical action of the jet, according to your opinion, was about 48¼ per cent.?—Yes; according to the measurement that I made at the time.

4515. Was that ascertained by shutting off the steam-jets, and then measuring the air with the boilers at work?—Yes.

4516. Was there any steam blowing off into the pit at the time?—No, I think not.

4517. Then, in point of fact, the difference would be, in your judgment, the mechanical effect of the steam-jets?—Yes; about 48 per cent., according to the experiment at Seaton Delaval.

4518. Are you aware whether the temperature was increased in the shaft at the time the jets were in use, as compared with the temperature when the jets were not in use?—I believe there would be very little difference; it was 136° in the shaft.

4519. At the time the steam-jets were on?—Yes.

4520. Did you ascertain the temperature when the jets were not on?—No; an accident happened to the thermometer, and we could not get it.

4521. The paper you have delivered in, does not give the temperature of the shaft during that part of the experiment in which the jets were not used?—No.

4522. You have heard it stated that, in the use either of steam-jets when they are placed too far apart, or of steam-jets used in cylinders when they are of too great a diameter, there is the return air down the inside of the tubes, which is called the pneumatic flower-pot?—Yes.

4523. Do you believe in that state of things?—I believe that if the steam-jets were placed at the top of the pit, that would be the case; but with the jets placed at the bottom, it is impossible, in my judgment, that it can be the case.

4524. You think that at the top of the pit it might occur, either in an open shaft or in tubes of too large a diameter?—Yes.

4525. Taking a jet of 3-16ths of an inch, and a tube 10 inches in diameter, can you form any judgment whether that would take place even at the top of the shaft?—At the top of the shaft it would take place; if there was the slightest defect in any of the jets, the air would be drawn down by the other jets.

4526. Is your opinion formed from the supposition of a defect in the arrangement of the jet, or, that as a scientific question it must be so, even when the jet is properly arranged?—I should not like to say that, if the whole of the jets were equally effective, it would be the case at the top of the pit; but in the experiments which were made at Seaton Delaval, when some of the jets were not so good as the others, the air went down.

4527. *Chairman.*] The air would go down one tube, and up the other tube?—Yes.

4528. Mr. *Locke.*] Supposing there was only one tube, and the jet was properly arranged at the top of the pit, 10 inches in diameter, and the size of the jet 3-16ths of an inch, do you think there would be any return air down the tube?—I think there would not.

4529. Your suggestion has been, that where there are defects in the steam-jets, as arranged in the cylinders, if one was defective the air would go down, and feed the force created by the other jets?—Yes.

4530. Supposing there were no other jets but that one, would the air return down that tube to feed itself?—My opinion is, that it would not.

4531. *Chairman.*] At the bottom of the pit, you conceive that it would be impossible?—Yes.

4532. Mr. *Ingham.*] How close are the jets placed to the floor of the pit?—I think perhaps about 12 feet.

4533. You do not think the air could descend so far as to get into the 12 feet and feed them?—It is quite impossible.

4534. Mr. *Locke*.] Can you state the velocity of the air going up the pit at Seaton Delaval producing the 88,000 feet?—The actual velocity in the upcast pit is 34 feet per second.

4535. *Chairman*.] The only case in which such circumstances might occur, would be the case of the airways being so small that they would not bring air enough to supply the intensity of the fires?—Yes.

4536. Supposing that the airways were sufficiently large, do you think it is impossible?—I think so.

4537. Did Mr. Wood, in his experiments, fail to develop the power of the steam-jet in consequence of the size of the tubes?—No, I should think not; because, I think Mr. Wood tried them with tubes and without tubes.

4538. In your opinion, is there any difference as to the direction of the steam-jets, in the way they are placed, as to the effect they will produce?—If they were placed together, the jets should be so placed as to go to the most effective point. I have looked at Mr. Wood's book this morning; and I think that in Table 15, page 58, there must be a mistake. The quantity of air per minute at 2 o'clock by the furnace, was 87,919 cubic feet, and the water-gauge at the west-door was 1.0. In the second experiment, the water-gauge is the same, and the quantity of air is increased, 30 minutes past 2 o'clock, to 101,137 cubic feet per minute. At 3 o'clock the water-gauge is the same, and the quantity of air is increased to 102,500 cubic feet per minute.

4539. You think that is a discrepancy which requires some explanation?—I cannot understand how the quantity of air at 2 o'clock and 3 o'clock should be 14,581 cubic feet per minute more, while the water-gauge is the same.

4540. Do you observe that, at one of the doors, at 30 minutes past 2, the water-gauge had increased?—Yes; but the west door ought to have increased in the same way.

4541. Directing your attention to the temperatures in those two experiments, you will find that the temperatures in both cases, at two different places, taken in the upcast shaft, is in one case from 144° to 158°, and in the other case from 138° to 155°?—Yes; but if you look below that, you will find it is down to 144°, where the greatest quantity of air is.

4542. The temperature in the one case is 144°, 158°, 160°, taken at 10 fathoms depth of shaft, and in the other case it is 138°, 155°, and 144°?—Yes; and then the 144° is lower, where he has got the largest quantity.

4543. You will observe, that making a comparison between the two experiments which you first gave, where the increase was from 87,000 cubic feet to 101,000 cubic feet, which is a large increase, there was a slight rise in the water-gauge, and a considerable rise in the temperature?—At one door, but not at the other.

4544. But there was a considerable rise in the temperature at both places of the shaft?—There was 14° at 10 fathoms up; and at 65 there is 17°.

4545. In the next experiment, where the increase was only from 101,000 cubic feet to 102,000 cubic feet, may not that slight discrepancy have been the result of calculation, or the want of accurate observation?—Certainly.

4546. Is a discrepancy of 1,000 feet in 100,000 feet, a very large difference?—No.

4547. Upon the whole, looking at these tables fairly, are the discrepancies such as would invalidate the general truth of the tables?—No.

4548. You have stated that the difference in the water-gauge between the experiment at two o'clock and at half-past three o'clock, is not sufficient to account for the difference between 87,000 and 101,000?—Yes.

4549. Mr. *Ingham*.] There is no difference in the water-gauge?—Not at one door.

4550. Mr. *Locke*.] Do you invariably find that, with an increased quantity of air, there is an increase in the water-gauge?—There ought to be.

4551. Do you find practically that it is so?—I have not paid much attention to the water-gauge; my object has always been to get a sufficient quantity of air.

4552. If you found that the water-gauge did not rise, even although you were getting a larger quantity of air, you would rely upon your quantity of air, and not so much on the water-gauge?—No doubt of it.

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4553. Is not the fairest way, in tables of this kind, to take rather the general results and general averages, than one particular experiment?—Yes.

4554. Are discrepancies often found, because, from the fire not being thoroughly burnt up at the time the experiment was commenced, or when an observation was made, an accurate result is not obtained?—Perhaps it may be so.

4555. And perhaps, upon a general average of the whole series of experiments, a tolerably safe result may be arrived at?—I do not find fault with the experiment; I only wanted to try if I could reconcile it.

4556. *Chairman.*] From your long acquaintance with Mr. Wood, have you any doubt in your own mind that he would take every means in his power to get the tables registered in the most correct way that he possibly could?—I have no doubt that he has taken every pains to do so, and that if there is any discrepancy it is accidental.

4557. Have you anything further to state with regard to your comparison between the ventilation of the Seaton Delaval colliery, and any other colliery in the district?—I think I made a mistake yesterday, in saying that the Hetton shaft was double that of Seaton Delaval; it is treble; it is 153 feet area, and ours is only 50 feet area.

4558. You consider that, if your shaft was as large as the shaft in Hetton colliery, you would get a greatly increased quantity of air?—Yes.

4559. Increasing the jets in the same proportion?—Yes.

4560. Mr. *Locke.*] Is there any peculiarity either in the workings, or in Seaton Delaval pit, making it different from other pits, that you have been obliged to abandon the furnace system, and apply the steam-jet?—I abandoned the furnace system, because I had the engine there; and I believed that the jets would be more effective, after trying the experiment, and after seeing it at the Polytechnic.

4561. Since that period, have you extended the use of the furnace to any other of your pits?—No; I have the furnace at the other pit. I am busy now with some experiments at South Hetton with the jets. But last year, when I was up before the Committee, we had not got the boilers up. We have put them in lately, and we have some steam-jets; but they are not exactly accurately set.

4562. You were understood to state yesterday, that you have only applied them at Seaton Delaval?—Only at Seaton Delaval.

4563. Since the experiments on the steam-jet have been made, have you turned your attention to improving the furnace system at the other collieries of which you have the superintendence?—I have furnaces at the other collieries.

4564. Do they work to your satisfaction?—Yes; we get a sufficient quantity of air to keep the mines safe.

4565. In proportion to the furnaces you use, and the area of grate you have, do you get as great a proportion of air through those pits, as you obtained at Seaton Delaval before you employed the steam-jet?—About the same.

4566. Not more?—Not more.

4567. Do you think that you have arrived at the maximum, in reference to the area of grate, in the experiment which was made at Seaton Delaval?—That I cannot say exactly.

4568. You did not, at that time, use the pure air of the downcast shaft?—No; I think much more depends upon the capacity of the air passages, than upon the furnaces or the steam-jet.

4569. That would apply to either system?—Yes; unless you have large air passages, you must not expect to get a very large quantity of air.

4570. Are the air passages at Seaton Delaval remarkably large for the extent of the workings?—Yes; unless they had been very large, we could not have got the quantity of air in.

4571. Have you enlarged them since you have used the steam-jet?—No.

4572. Is not the drift from the downcast to the boiler furnace something new?—No.

4573. Did any air pass through that drift, at the time the furnaces were at work?—Yes; the boilers were fed with the fresh air, when the furnaces were at work.

4574. In the same manner as now?—Yes.

4575. And the circumstances are all the same?—Yes; I think that the greatest attention ought to be paid to the air passages.

4576. Are you aware that Mr. Wood has not, in any of his experiments, been able

able to obtain such great results from the use of the steam-jet, as you have obtained at Seaton Delaval?—I do not know that.

4577. Can you assign any reason why the result of his experiments has not been so great as your own?—No; I do not know the size of his airways, or how he made the experiments.

4578. You think that, in order to make a fair comparison of experiments of that kind, you ought to know the size of the airways, and have all the other circumstances before you?—Yes; Mr. Wood had a greater distance, and his airway passages were much longer than the air passages in Seaton Delaval. There is no doubt that would have an effect against the steam-jet. I understand that his air passages amounted to 96 miles, whereas in Seaton Delaval they amounted only to 14 miles.

4579. *Chairman.*] In your opinion, for the purpose of ventilation, is the steam-jet more economical than the furnace?—We find it so at Seaton Delaval.

4580, At Seaton Delaval you had an engine which was working before?—Yes.

4581. Supposing you had to provide boilers entirely for the steam-jet; in your opinion, which system would be the most economical?—I think the boilers would be as cheap as the furnaces; our two boilers at Seaton Delaval have only cost 45 *l.* in repairs, during nine years. No part of the machinery of the engine has anything to do with the steam-jet; it is merely the boilers; but, again, that depends on the state of the water with which the boilers are fed; if you have bad water, the boilers will require more repairing.

4582. Mr. *Locke.*] Have you good water at Seaton Delaval?—Yes.

4583. *Chairman.*] In your opinion, is sufficient attention paid to the capacity and the size of the airways generally?—I think not, generally speaking; I think that the airways are far too small.

4584. Do you think that sufficient care is taken to keep the airways open, and to clear them from falls?—In the north of England, I believe that every attention is paid to keeping them open; but still I think they are not large enough.

4585. Whatever power you put on, either by furnace or steam-jet, you could not arrive at the extreme power that the furnace or steam-jet was capable of producing, unless the airways were sufficiently large?—No.

4586. In your opinion, is it not the threshold of ventilation, so to speak, to produce a great current down the pit; and ought not much more attention to be paid to splitting the air?—Yes; there is no question that the distribution of the air is a very material point indeed.

4587. Is that sufficiently attended to in the north of England?—I think so.

4588. Have you acquaintance with any other districts?—Yes; I have been in Lancashire, in Scotland, and in Wales.

4589. Is the system of splitting the air understood in those other districts?—I think they are getting more into it than formerly.

4590. Is it as easy to split the air in those districts as it is in the north of England?—Yes; the point is to observe where it ought to be split; otherwise, instead of doing good, you might do harm, by splitting it at an improper place.

4591. Is the object of splitting the air to shorten the current, and give each man his proper proportion of fresh air?—To give each of the working districts fresh air; if you were to let the whole current, in Seaton Delaval or Hetton, go round the whole of the workings, you would not have so considerable a quantity.

4592. Nor would the men be in such a healthy state?—No.

4593. With respect to the goaves, would you clear them entirely from foul air, or would you block them up?—I would deal with them as they are dealt with in the north of England; namely, to allow the return air to sweep past the edge of the goaves, so that if any gas escapes from the falling barometer, it is swept away by the return air.

4594. Would you keep the goaves entirely open?—I would not recommend them to be blocked up. If gas comes into the return passages, it is swept away by the current of air, and is not allowed to accumulate. While the gas is in the goaf, and not mixed with atmospheric air, it is harmless; but when it comes out of the goaf, and is mixed with atmospheric air, it becomes dangerous; consequently, it ought to be swept away immediately.

4595. Is that generally attended to in the north of England?—Yes; as far as I have seen.

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4596. Mr. *Locke.*] You have been understood to state that it was much better that the gas should not be permitted to accumulate in the goaf, and that you would not close it up?—It should not be allowed to accumulate in the air passages; it will be in the goaves; if the glass rises, it disappears, but if the glass falls, it comes down; the pressure is taken off, and the gas escapes.

4597. As a matter of precaution, would you close up the goaves, and keep the gas from the surrounding current?—No.

4598. Do you think it is better to permit it to be swept away by the ordinary currents on the edges of the goaves?—No doubt of it.

4599. *Chairman.*] In all cases of explosions, where large numbers of lives have been lost, in your opinion, have those lives been sacrificed from the force of the explosion, or from the after-damp?—The great bulk of them from the after-damp.

4600. Has that arisen from the blowing away of the stoppings and doors?—Yes, and completely deranging the ventilation.

4601. In your opinion, is it a proper arrangement to have doors to return the air?—You cannot do without doors, but the fewer doors that are used the better.

4602. Mr. Wood, in describing the ventilation of one of his collieries, stated that he had no doors except between the two pits, and that all the air was turned by small openings, by leaving the openings proportioned to the size of the airways?—That is, by what we call a regulators.

4603. In your opinion, would that system decrease the danger in cases of explosion?—No doubt of it; but still you cannot do without doors, in some cases.

4604. Could not an extra door be always placed alongside the ordinary door, which could be propped up; so that if the ordinary door were blown away by an explosion, the prop might be blown away, and the door (which would be a species of trap-door) might fall down and keep up the ventilation?—The prop, and door, and everything, would be blown away. In all the main ways, where there is one door required, there are always two set; so that in case the boy should fall asleep and neglect it, there is the other door to rely upon.

4605. In cases of explosion, do the men generally lose their lives by endeavouring to find their way out of the shaft?—Yes; it is very natural that they should endeavour to make their way to the bottom of the shaft as quickly as possible. First of all, they get into a sort of nitrogen gas when they hold their heads up, and then they fall down into a more dangerous gas, namely, carbonic acid, and they are soon destroyed. I have seen a man, after an explosion, when he got among the choke-damp, had taken his cap off his head, and put it in his mouth, and not a hair of head was injured, but he was quite dead.

4606. What is the best course for a man to pursue in case of an explosion?—It is quite impossible to say; if the stoppings and all those things are blown out, there is very little chance for him, if he has any distance to travel.

4607. Mr. *Locke.*] Would not his best plan be, to make his way as fast as he could to the downcast pit?—He always does that. I know an instance of an explosion at Houghton-le-Spring, by the blowing out of the air crossing, where nearly the whole of the men were saved in that way. The explosion happened to be on the outside of the air crossing which was blown down; and the men beyond that point, when they came up to it, found there was bad air, and they stopped. If they had come on, they would have been all lost by the choke-damp. So that it tells both ways. That air crossing saved the great bulk of the men.

4608. Those men would not have been able to gain the air course from the blowing out of the stoppings?—They stopped where the air was good. There was sufficient air to maintain them until assistance was brought to them, and means found to give them fresh air.

4609. *Chairman.*] Do you think that refuge stalls would be any advantage?—None.

4610. Mr. *Locke.*] Why?—Because the refuge stalls would soon be filled with choke-damp.

4611. You think they would not be practically useful?—Never.

4612. *Chairman.*] It appears, by the returns which have been laid before the House of Commons, that a great number of lives are lost by falls from the roof; can you suggest any means of obviating those accidents?—I can suggest nothing but setting timbers to support the roof, and even then accidents will happen.

I had an accident from a falling of roof last December. I had passed through the place, and I saw nothing amiss; the stone seemed to be all good, the width was only four feet, and on returning it came down upon me 8 yards long, 3½ feet wide, and 10 inches thick; and there I was under it for eight minutes.

4613. Were you much injured?—I was injured in my leg, arm, and shoulder; I was confined to my house for six weeks.

4614. In the north of England you have deputies, whose particular duty it is to set the timbers?—Yes.

4615. In some parts of England do the workmen set their own timbers?—Yes.

4616. In your opinion, which is the best system?—I think it is much better to employ people purposely to set the timbers, than to allow the workmen to set them.

4617. Do not you think the workmen would have sufficient regard to their own lives to take proper care that sufficient timber was set, if they were paid for setting the timber themselves?—Some of them would run the risk rather than set a prop. It is much better to employ men to set the timber, because they are responsible in case of any neglect.

4618. In general in the north of England is sufficient timber furnished in all the collieries?—Yes, there is no want of timber; at least, I think no viewer in the north of England would continue in office if he was not supplied with sufficient timber to keep everybody safe; at any rate, I would not; I must have my men kept as safe as possible. Accidents will occur, after you have taken all the precautions in your power.

4619. Do not you think that a head viewer incurs immense responsibility, and is liable to great blame, if he does not take every precaution to preserve the lives of his men?—Yes, I think it is a very great responsibility.

4620. Do you feel that responsibility yourself?—I do.

4621. It appears also by the returns which have been furnished, that about 200 lives a year throughout England are lost in winding persons up the shafts, from accidents from engines and machinery, breakage of ropes, and other things?—I think that only a small portion of that will be due to the north of England.

4622. In the north of England are the men wound up at more rapid rates than in any other part of England?—Yes; but we always have good ropes, good machinery, and good cages for the men to stand in.

4623. In the north of England is it the invariable custom to cover the men, so that, if anything should fall from the sides of the pit, it will not fall on the heads of the men?—Not always.

4624. In your opinion, should that system be universally adopted?—I do not think it is so necessary in the north of England as it is in other parts, for great pains are taken with the shafts, to ensure that nothing shall fall out; there is no rubbing against the sides of the shaft. The cage is run on slides; so that there is no wear and tear of the shaft at all.

4625. Mr. *Locke.*] Are the slides of iron, or of wood?—Wood generally.

4626. *Chairman.*] At the same time, however good the pit may be, and however good the slides may be, is it not possible, that from a jerk of the engine, or from some other cause, a piece of coal may fall out of a waggon in coming up the pit when the men are going down?—I never allow the men to ride when coals are coming up.

4627. Is that a regulation which should be universally adopted?—No doubt of it. I think it is not right that men should go down while coals are coming up.

4628. Is that a regulation which should be enforced by law?—Yes.

4629. Supposing a pit was in bad repair, although you had cages might not some pieces of the pit fall out, and fall on the heads of the men?—In that case it would be better to have the cages covered over.

4630. That would not be much expense?—No.

4631. Looking at the extra security, and at the slight expense to which the coalowners would be put, do you recommend that the top of the cage should be covered over, so as to prevent accidents?—Yes; I think it might be the means of saving the lives of some of the men; and I think it ought to be done.

4632. Mr. *Locke.*] Do you think that a cage is necessary, where coal is not pulled up a pit at the time the men are going up or down?—Yes.

4633. You suggest that as a remedy against a piece of stone which might be liable to fall out from the sides of the shaft?—Yes.

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4634. Do not you think it would be better to legislate against the actual condition of such a shaft, than to legislate for something which is to admit such a dangerous position in a shaft?—The best remedy would be, to make the shaft secure.

4635. You have been understood to state, that in the north of England the shafts are in such a state that such accidents rarely or never occur?—Very seldom.

4636. Do not you think it is much better, if there is to be any stipulation at all, to make the stipulation on the shaft rather than on the cage, which is virtually admitting the necessity of a bad shaft?—Yes; but I would not only have the shafts put right, but also secure the cage, because a little bit of stone might come out.

4637. At all events you would make it the first condition, that the shaft should be in good order?—No doubt of it.

4638. *Chairman.*] It is possible that a piece of material of some kind might come from the top of the pit?—Yes. In an upcast shaft the sides are more liable to waste than in a downcast shaft.

4639. Provided a shaft be in the most perfect state, there is still danger that a piece of material, or something or other might fall from the top of the pit; and, if there was no cage, it would fall on the heads of the men, if the men were perpendicularly under it?—Yes.

4640. Do not you think it would be a good regulation to enforce, that covers should be placed on the tops of the cages?—No doubt of it.

4641. In your opinion, is sufficient care taken to keep the machinery and ropes in good order, generally, in England?—In the north of England I think that every care is taken.

4642. In other districts, do you think that sufficient care is not taken?—I think it is very objectionable in some districts, where they have engines on the second motion, and where they can put them out of gear; they sometimes get out of gear, and the rope runs amain. I think something of that sort happened in the neighbourhood of Bristol, where some people were killed.

4643. Should it be one of the duties of the inspectors to see that the machinery and the ropes were in good order?—No doubt of it.

4644. It has been stated in evidence before this Committee, that the limit of age of persons who are employed as engineers, to wind men up and down a pit, is 15?—We do not have such a thing in the north of England; they are always upwards of 20.

4645. In your opinion, should any person under 18 years of age be employed as an engineer, to wind men up and down pits?—No. I think that 18 is as young as they ought to be employed in winding men up and down.

4646. Do you see any objection to the Legislature enforcing such a regulation?—None.

4647. Mr. *Locke.*] Would you apply that to all pits?—Yes. Where men's lives are in the hands of the engine-man, he ought not to be under 18 years of age.

4648. Mr. *Ingham.*] That is, what you call the breaksman?—Yes.

4649. Mr. *Mostyn.*] Do the inspectors in the north of England always direct their attention to the state of the ropes and machinery?—I suppose they look at them. More pains are perhaps taken with the machinery and ropes in the north of England than in any other district. In some places we use Fourdrinier's safety apparatus on the cages.

4650. *Chairman.*] Where have you used Fourdrinier's safety apparatus?—At South Hetton. We have a shaft purposely for sending down the men, and for bringing them up.

4651. Have you used Bell and Grant's apparatus?—That is on the same principle.

4652. It has been represented to the Committee, that there has been no decrease of accidents in consequence of using such apparatus, because if anything gets out of order they get fast in the slides?—In a shaft where there is nothing but men going up and down, they are not liable to get wrong; but in the coal working shafts sometimes they are liable to get wrong; and the consequence is, at present, that where they are not used the ropes are particularly watched; but where they are used, the ropes are perhaps used longer than they ought to be, and hence some of the accidents.

4653. Is

4653. Is it your opinion that, however excellent Fourdrinier's apparatus may be, it engenders carelessness as to the condition of the rope and machinery?—Yes; and it is also liable to get out of order.

4654. You have spoken of winding the men up a separate shaft. Is that the custom?—No; it is not by any means the custom; but we have a spare shaft, and it being a very deep pit, we use that shaft for sending the men down, and bring them up.

4655. That is the exception, rather than the rule?—Yes.

4656. The general rule is, that men are wound up and down the same shaft that the coal is wound up and down?—Yes.

4657. That being the case, what is you opinion as to the utility of Fourdrinier's and Bell and Grant's apparatus?—I would rather prefer watching the ropes, than having those things.

4658. Taking such precautions as you have already mentioned?—Yes. The ropes are particularly attended to in the north of England; they are always put in the charge of the engineer of the colliery, whose duty it is to watch them daily; we never have such a thing as a broken rope in the north of England.

4659. Do you make the man whose duty it is to watch them personally responsible, if an accident happens through his carelessness?—Yes.

4660. Mr. *Ingham.*] Are the ropes of hemp or wire?—I use nothing but wire rope.

4661. *Chairman.*] Is it your opinion that, in very fiery mines, the use of the safety lamp should be enforced by the Legislature?—It ought to be enforced where it is really necessary to be used; but where there is blasting by gunpowder it is very difficult to use it entirely.

4662. Do you think that safety lamps are a lure to danger, or that they are an extra safeguard?—I think they are a safeguard.

4663. Have you any doubt in your own mind of the success of the safety lamp in guarding men from being burnt?—I think there is no doubt that the lamp is a very great safeguard; but I should like to have a better lamp, if we could get it.

4664. You do not give these answers with reference to paying less attention to ventilation?—No.

4665. Your opinion is, that the first thing to attend to is to have proper and sufficient ventilation through the pit?—Yes.

4666. As an extra security, you would recommend the use of the safety lamp, where a great quantity of gas is generated from the coal?—Yes; I would never allow the men to work with the safety lamp, where the gas explodes in the cylinder of the lamp.

4667. Would you stop the working until you had obtained a better ventilation?—Yes; I would withdraw the workmen, and every one, as soon as that was seen.

4668. In the neighbourhood of goaves, where you are constantly liable to variations of temperature, do you think it is safe at any time to use naked lights?—No; we never do.

4669. Would not that apply, in a fiery colliery, to cases of blowers and accumulations of gas escaping from the stratification also?—If there is a good ventilation in the whole mine, there is not much chance of any accumulation of gas, if it is properly attended to. In the neighbourhood of goaves, and taking away the pillars, in all fiery mines the safety lamp is used.

4670. Have you known the safety lamp explode, and a serious accident occur, from that cause?—I do not know it of my own knowledge; but we had an accident at Haswell nine years ago. When an explosion occurs, there is no one left to tell how it happened.

4671. Has anything occurred to shake your confidence in the safety lamp?—I think the safety lamp ought not to be trusted in the hands of men in an explosive mixture. I have been in gas where the lamp has been red hot, and still I had full confidence; but I would not like to trust it, in such a mixture, in the hands of working men.

4672. With ordinary care and attention, you have no doubt of the advantage and utility of the safety lamp?—No; but in such a mixture, a man in working might, by accident, put his pick through the lamp.

4673. Mr. *Locke.*] You have been understood to state, that you would not

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allow the working men to remain after a certain time, namely, when the gas filled the inside of the lamp with flame?—I never do.

4674. You would not allow a man to continue to work, if the lamp was red hot?—Certainly not.

4675. And therefore that danger you would not fall into, because you would never allow them to work so long that the lamp should get red hot?—No.

4676. Was there anything in the accident which you have mentioned as having occurred at Haswell, which bears on this question?—The explosion occurred where the safety-lamp was used. At the moment the accident happened the deputy was drawing the timber out of the mine, where the coal had been taken away, and the lamp had either been defective or the fall of the roof had driven the flame out of the lamp.

4677. All these suppositions arose at the time?—Yes.

4678. Do you recollect whether any exploded lamp was found, or in what state the lamp of the overmen was found?—The lamps were found, but they were very much knocked about; and we could not make out whether they had been defective before the accident occurred.

4679. Was the gauze bulged?—Yes.

4680. Whether that arose from the effect of the explosion or not, you were not able to tell?—No.

4681. Mr. *Ingham.*] How many survivors were there?—None in that pit; they were all lost.

4682. Mr. *Locke.*] How many were lost?—Ninety-five.

4683. *Chairman.*] Have you read Mr. Wood's experiments on the safety-lamp?—Yes.

4684. Do those experiments tend to increase you faith in the safety-lamp?—No; I have the same opinion. I think that the flame might be driven through the gauze of the lamp by a fall of stone.

4685. Mr. *Locke.*] That is, the fall of stone producing an action on the air?—Yes.

4686. *Chairman.*] Provided safety-lamps are used in the neighbourhood of goaves, in your opinion, should the collier be able to open the top of his lamp?—No; and in the north of England they are never allowed to open them.

4687. A case occurred the other day, at a place called Bent Grange, in which the overman saw a man working with the top off his lamp, and virtually connived at it, by neglecting to order him not to do it; do you think that is a system which should be tolerated?—Not for one moment.

4688. In your opinion, should there be one man appointed in the pit to have the superintendence of the safety-lamps, cleaning, repairing, and putting the oil into them?—Yes; in the north of England there is a man who has the charge of all the bottoms of the lamps; the men take the gauze home and clean it themselves; but he cleans the bottoms, and puts in the fresh wick and oil. The men, as they come down the pit in the morning, get their lamp-bottoms, and then they go to their respective districts and places appointed by the overmen; the deputy-overman of each district examines the gauze properly to see that it is all right; he then screws on the top and locks it, and the man goes to his work. One man could not examine the whole of the lamps in a pit; but each man, in his respective district, examines them and locks them; and nobody in that district can open a lamp but the deputy.

4689. Are the locks so constructed that they cannot be opened without great force?—They would have to injure the lamp before they could take them off.

4690. Mr. *Ingham.*] You said that you would like to see a better lamp?—Yes. I should like to see a lamp that could not be injured by the blow of a pick; or a lamp that would go out as soon as it got into an explosive mixture.

4691. *Chairman.*] Have you ever seen Eloin's lamp?—Yes.

4692. Does that lamp go out in an explosive mixture?—It is too delicate; if you take a false step it goes out.

4693. Mr. Wood, in his experiments, objected to glass lamps having gauze, because there is a danger arising from water breaking the glass, and an additional danger of the force of the current driving the explosive mixture through the gauze; is that your opinion?—Yes. Still I think that Dr. Glover's lamp is the best lamp; it has two glasses, and the air goes down between them, and feeds the light.

4694. Provided that Dr. Glover's lamp had a double gauze all the way down, do

do not you think that would be a great improvement?—Yes. I have one objection to it, namely, that it is rather too complicated; there are too many little things to attend to, which sometimes get lost. The Davy lamp is very simple.

4695. Do you think that less accidents have occurred in collieries since the present mode of inspection than before?—I think not much in the north of England.

4696. Are you satisfied with the present mode of inspection?—If there is to be inspection at all, I think there ought to be more inspectors.

4697. What is your opinion of the class of gentlemen who are now the inspectors of mines?—I think that most of them want a little more experience.

4698. You said, "If there is to be inspection at all." Is it your opinion that it would be better to have no inspection of any kind?—I do not think it has done much good in the north of England, and perhaps in other districts it has done harm.

4699. How?—Because, before the inspectors were appointed, they had not as much atmospheric air in the mine as to make the gas explosive; and now they are getting them to put in a little more air, which makes it dangerous, supposing there is not enough air in the pit to render the gas explosive.

4700. Would not such a state be highly detrimental to the health of the men?—No question of it; but they ought to get a larger quantity of air put into the mine, to place it beyond the dangerous point.

4701. Supposing an additional improvement were to take place; now that so much air is carried into the mines, as to render them dangerous from explosion, if it was the duty of the inspector to see that an additional quantity was carried in, so as to free the mine from danger, do not you think that would be a great improvement?—Yes; but the inspector ought to see that the air passages were enlarged.

4702. Is it your opinion that each inspector has at present a great deal too much to do, and therefore cannot pay sufficient attention?—They have too many pits to attend to, and I do not think they go down the pits as often as they ought.

4703. In the north of England in general the pits are very well managed, and much better than in other districts?—Yes.

4704. Therefore, in the north of England you would have less fear of an inspector than would be felt where the pits are badly managed?—Yes; still, if inspectors are appointed, they ought to go down a certain number of pits in a week. I think it would not be too much to ask them to go down three pits in a week.

4705. How many times in a year should an inspector visit each particular pit?—At least once a quarter.

4706. One pit every quarter?—Yes.

4707. How many pits ought he to have under his superintendence?—He could visit about 50 pits.

4708. In your opinion, 50 pits would be ample?—Yes.

4709. At present each inspector has something like 400 pits under his charge?—Yes.

4710. Therefore, whatever may be his industry and energy, it is impossible for him to perform the duty of inspection satisfactorily?—Still he ought to go down the pits.

4711. Do not the inspectors go down the pits now?—Very little. I have been a pitman 36 years, and I have averaged, during that time, four days a week; and I do not see why they should not go down three times a week.

4712. Mr. *Locke*.] Can you state to the Committee how frequently they go down?—I should think that the inspector in the north of England has not been down 30 pits in three years.

4713. How does the inspector get his information?—He goes to the colliery and applies to the resident viewer, and asks him the state of the mine, and makes minutes.

4714. Do you suppose that that is the general mode in which inspectors derive their information for making their reports?—Generally speaking, it is.

4715. You think that that is not a desirable mode?—I think it is better that an inspector should go down a pit and see it before an accident happens, than to go down after an accident, and give evidence before a coroner's inquest.

4716. Do you think it would be fair to the proprietors of collieries, that they should be subject to orders, rules, and regulations laid down by a body of

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inspectors, who did not themselves go down the mines?—Certainly not; and I think the inspectors should not be allowed, as I understand from the Act of Parliament they were not to be allowed, to take any other work.

4717. Is not that provision of the Act carried out?—No; I am aware that, at the time the accident happened at Killingworth two years ago, Mr. Dunn, the inspector, was surveying a pit in Lancashire, and was not in the neighbourhood.

4718. Do you mean that he was surveying for other parties, and not for the Government?—Yes.

4719. Then, in point of fact, you think that the regulations which it was intended should be carried out have not been enforced?—No. I have heard of another instance, although I do not know it of my own knowledge; I have heard that Mr. Wynne attends arbitration cases. I think that he would be much better employed as an inspector, and looking after the mines under his charge.

4720. Are the Committee to understand that the inspectors, some of whom have given evidence here, are not in the habit of going down the mines very frequently?—I can only speak with reference to the north of England; I know that Mr. Dunn has not gone down frequently.

4721. You think that it is too much to expect, that coal proprietors would desire to be bound by any regulations from parties who do not make a personal examination of the mines?—They ought not only to go down the mines, but, in my opinion, it is their duty to go down and see that the air passages are sufficiently large for the ventilation of the colliery.

4722. For that purpose, you would require, of course, a good practical man, who was competent to judge of the largeness of the air courses?—No doubt of it. If a code of rules were laid down for the guidance of the inspectors, they would see what size the airways ought to be.

4723. What do you think about the appointment of sub-inspectors?—I do not think it would answer in our district, because the sub-inspectors and the overmen would be constantly quarrelling.

4724. Do you think that the superintendence of your mines is sufficient by the overmen, sub-viewers, and others, and that it is unnecessary to have any further superintendence?—That is my opinion.

4725. It is your opinion, that if there is to be inspection at all, you require a man who is thoroughly competent to judge of all the practical requisites of working a mine, and to see with his own eyes, before he gives an order, the necessity for such an order?—No doubt of it.

4726. Do you think it would be fair towards the coal proprietors that Government should institute any orders or any rules, to be enforced by men who do not go down the mines themselves?—Certainly not.

4727. Mr. *Ingham.*] Should they have authority, after they had observed that an alteration ought to be made, to direct it to be executed?—No; I think they ought to make, as they do at present, suggestions, and that beyond that they ought not to go; for this reason, that if they have power to order them, they must take the responsibility.

4728. *Chairman.*] Would you give no power to any higher authority than the inspectors?—Yes; I should have no objection to its being placed in the hands of the Board of Trade, in a similar way to railways.

4729. Mr. *Ingham.*] Then if the suggestion was not acted upon, would you give coercive power?—If an accident occurred, the proprietor of the colliery or the manager would be liable to be dealt with according to Lord Campbell's Act.

4730. *Chairman.*] In your opinion, the Board of Trade would be the proper tribunal to have the superintendence of mines?—Yes; all orders should emanate from them, and also the appointment of inspectors.

4731. As the President of the Board of Trade would not have time to look into these matters himself, would it be desirable to appoint a gentleman of great practical knowledge and scientific experience, to have the control of all the inspectors?—No doubt of it.

4732. In case of his having any difficulty, do you think that he should consult with the directors of the School of Mines in London?—I am afraid that they are not sufficiently up to the practical working of a colliery, to give much assistance.

4733. Mr. *Locke.*] Do you suppose that the professors in the School of Mines

Mines would understand anything about the practical working of a colliery?—No.

4734. You put your faith in men who thoroughly understand the under-ground working?—Yes.

4735. You are of opinion that the complicated nature of air-ways, the mode of ventilating and distributing the air, setting the props, and attending to all the details of the mine, are such as to justify you in thinking that only from a practical man could you have perfect security?—A practical man should be the individual to examine the mines; but I should have no objection to their management being vested in the Board of Trade, under the superintendence of a gentleman to be appointed by Government; and that all the reports of inspectors, and any observations which the coalowners wished to make, or any complaints against the inspectors, should go direct to the gentleman at the head of the Board of Trade.

4736. You think that where there is power there should be responsibility?—As far as I am concerned, if the responsibility were taken off my shoulders, I should be very glad.

4737. Supposing that an order which had emanated from the Board of Trade, or from the gentleman who was appointed by the Board of Trade, should miscarry in any manner (and you know, perhaps, as a practical man, that they do sometimes miscarry in their execution), would it be fair on the proprietor that he should be made answerable for the consequences of that order of the Board of Trade, or should the Board of Trade take the responsibility?—The proprietor of the colliery should not be answerable for any order that miscarried, which had been issued from the Board of Trade.

4738. Supposing the Board of Trade ordered the distribution of air in a particular way, and that resulted in an accident, and a practical man gave evidence before the coroner's jury that that was a bad arrangement for the distribution of the air, do you think it would be fair, under those circumstances, that the proprietor of the colliery should have claim on the Board of Trade for their misdirection?—I think he ought.

4739. *Chairman.*] Would you give a power to the superintendent or to the inspector to stop a mine under any circumstances?—I think not.

4740. Take a case which happened the other day at Bent Grange, at Oldham. It appears that the inspector had two or three times warned the proprietor of the mine that it was in a dangerous state, and recommended him to put up a furnace and improve the ventilation, and also to prevent the men from taking the tops off the safety-lamps; that the overman had promised a short time before that he would put up a furnace, and that he neglected to do it; and that in consequence of the top being off a lamp the mine exploded, and killed 20 men. In a case of danger of that kind, where the proprietor of the mine has refused or neglected to put his mine into a safe condition, do not you think it would be well that there should be some person to step in and stop the mine?—I think that the Government of the country should institute proceedings against the proprietor.

4741. Mr. *Locke.*] Do you see any objection to placing such an absolute power in the hands of persons who are perfectly competent to judge upon such a question?—I certainly should object to give the inspectors such a power.

4742. You have been understood to state, that in your own practice, you positively forbid any man to work from the moment the lamp becomes filled in the gauze by the flame?—Yes.

4743. As a practical man, you think it unsafe then to work the mine?—Yes.

4744. If you were a Government inspector, and you gave that order, and that order was not attended to, and an accident occurred, would you think that the parties disobeying the order were liable to punishment of some kind?—No doubt of it.

4745. Then if the Government were to appoint a person, as competent as yourself, to see that no man in the kingdom was permitted to work mines, except under certain rules and regulations, such as those which you have laid down, do you see any harm in the Government enforcing such regulations?—If rules are laid down beyond which inspectors have no power to go, then I should have no objection to it.

4746. Do you think it is possible to lay down a certain number of simple

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rules for the guidance of all persons who are entrusted with the superintendence of collieries?—Yes.

4747. Do you think it would be a good preliminary to the establishment of any inspection, that there should be some sound general rules with which practical men like yourself should be made acquainted and approve of?—Yes.

4748. Do you think there would be any difficulty in framing such a set of rules as have been alluded to, which would give satisfaction to the coal-owners and the men?—I think there would be no difficulty in it.

4749. You have been understood to state that the inspectors, who were intended to devote their whole time to the duties of inspection, have, to your knowledge, been employed in other business than that of inspecting collieries for the Government?—Yes.

4750. Do you think that, while this Committee is discussing the question of the propriety of appointing more inspectors, it is desirable that whatever inspectors are appointed, their attention should be devoted exclusively to the duties of inspection?—There is no question of it.

4751. *Chairman.*] In appointing the inspectors, it was not contemplated that they should transact any other business?—They have gone out of the course.

4752. Mr. *Mostyn.*] You have stated that the inspector of the North Wales district, Mr. Wynne, has been engaged in arbitration cases?—I heard a gentleman say so.

4753. You are of opinion that an inspector cannot properly inspect more than 50 collieries per annum?—No; if he has to go down them every quarter.

4754. That is the number you recommend?—I think that if his inspection is to be useful, he ought to make those periodical visits, and examine a pit thoroughly when he goes down.

4755. You have also been understood to state, that you think the inspectors ought to be exclusively employed in the duty of inspection?—Yes.

4756. *Chairman.*] Do not you think that this Committee would be rather wasting their time in recommending the Government to appoint extra inspectors, if the present inspectors are doing other work besides that for which they were appointed?—Yes; still, with the present number of inspectors, there is no chance of their visiting the collieries as often as they ought to be visited.

4757. Mr. *Locke.*] It has been stated before this Committee, that every pit ought to be examined at least once a year; you have formed your opinion upon the necessity of its being visited once a quarter?—Yes.

4758. Suppose it is visited once in six months?—In that case half the number of inspectors would be sufficient.

4759. Do you think that, for a practical and sufficient inspection of mines, once in every six months, good practical men could be obtained in this country?—I think they could.

4760. You think that good men so appointed, having nothing else to do, might probably make a very efficient inspection of the mines in this country, by visiting them once in six months?—Yes.

4761. And that every superintendent would be enabled to examine 100 pits?—Yes.

4762. You think that would form a very fair basis for estimating the number of men to be appointed?—It must depend upon the power they are to possess. If they are to have the power of ordering, then they must go down oftener than once in six months. With proper regulations, once in six months would be sufficient.

4763. You have stated that you do not apprehend any difficulty in framing regulations?—I think that there would be no difficulty.

4764. You think it would be the easiest and most satisfactory mode to have those rules in the first instance, and that the inspection should not be quite so frequent as three months, but once in six months?—I think it would be more satisfactory to the proprietors, and to the inspectors themselves, to have those rules laid down.

4765. *Chairman.* You think that, those rules being laid down, there would be no difficulty in getting proper inspectors appointed, who would give satisfaction to the coal proprietors and to the workmen?—I think not.

4766. Mr. *Mostyn.*] And that they would undertake to inspect 100 collieries annually?—That should be a stipulation of their engagement.

4767. *Chairman.*] You are of opinion that the workmen themselves should see the rules which were made, in order that they might be satisfied that the rules

rules were framed with a due regard to the safety of their lives?—No doubt. I think that the men, whose lives are at stake, should be satisfied that a mine is in a proper state.

4768. Mr. *Locke.*] The rules would be put up, and the workmen would know what they were, and would always have an opportunity of suggesting alterations or additions to them, if they thought proper?—No doubt of it.

4769. In your experience, have you always found that the managers of collieries have attended to any suggestion which was made by a workman, if it was at all calculated to diminish the risk to life or to accident in a mine?—I always encourage my men to speak, if anything is amiss; because I tell them that, if there is anything wrong, the sooner it is rectified the better; and, instead of dismissing them, I thank them for telling me.

4770. Mr. *Ingham.*] Are you aware that that is not the universal practice?—Perhaps it is not the universal practice; but it ought to be.

4771. Do you think that there are means by which an inspector can place himself in that relation with the men, in which you place yourself with your men, and encourage such representations to be made?—I think he might. I should tell my men, in the presence of the inspector, that if they saw anything wrong, and did not like to speak to me, to speak to the inspector, and that I should be obliged to them to do so.

4772. Might that be made part of the general regulations?—Yes.

4773. Mr. *Locke.*] Have you generally found that a very strong feeling exists against workmen who make representations of that kind?—Sometimes; but I hope it is not generally so.

4774. Do you think it is the general rule?—No, I think it would be the exception.

4775. Mr *Ingham.*] It is not alleged that that has been the feeling, but that some of the men, whose default possibly is the matter complained of, and who fill a subordinate position in a colliery, come immediately in contact with the men, and can make their situation unpleasant, without perhaps the head viewer or proprietor knowing anything of it?—When a man complained at the office, he should be heard; and the man who annoyed him for so doing ought to be discharged.

4776. Mr. *Locke.*] According to your experience, he would be dismissed?—He would be dismissed by me.

4777. *Chairman.*] Personally, you would not keep a deputy or under viewer, who pursued the course which has been alluded to?—Certainly not. I think that the men have a right to be heard, that their complaints ought to be examined, and that if anything is wrong it ought to be put right.

4778. Do the men ever come to you with complaints?—Yes; and their complaints are always investigated.

4779. You have published a set of rules for the use of your collieries?—Yes.

4780. Those rules have been published in the evidence given before the Committee of 1852?—Yes.

4781. Have you since altered those rules?—I have made one alteration, but it is not of any consequene.

4782. Then those rules may virtually be considered in force?—Yes.

4783. Have you found any difficulty in enforcing them?—None. I have had only one infringement of those rules during the last 12 months; and that was the case of a man at Seaton Delaval colliery smoking his pipe while he was using the lamp.

4784. Mr. *Locke.*] Did he light his pipe at the lamp?—No; he went into the place smoking his pipe, and I detected him myself.

4785. *Chairman.*] Do you think the workmen often commit acts of careleness of that kind?—No. I have always found my men very attentive to the rules, and very obedient and anxious about the safety lamps. Not a man whom I employ would go past the place where his lamp has to be examined, without its being looked at and locked.

4786. Mr. *Ingham.*] From what class of men do you generally select your overmen?—They are first of all hewers; from hewers they become deputies; from deputies they become back-overmen, and from back over-men they become overmen.

4787. They are not merely persons of manual skill, but of general knowledge?—Yes, of general intelligence and good education; they can read and figure well.

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4788. Do not you think they possess sufficient self-control not to quarrel with the sub-engineer?—It might be that the sub-inspector would quarrel with them.

4789. Would not the class of men who are selected as overmen form a good class to be translated into sub-engineers?—No. They might take their instructions very quietly from the under-viewer who had charge of them, but they would not, perhaps, like to take them from a sub-inspector who had nothing to do with them.

4790. *Chairman.*] In Monkwearmouth an accident occurred, by which four men were killed, in consequence of a shot of gunpowder being let off in a pit where there was a great accumulation of fire-damp: in your opinion, is that a dangerous practice?—I think, in that instance, the men being at work by the long wall system, and the goaf being constantly within six feet of the face of the working, it was not safe or prudent to fire shots.

4791. You think it was not safte or prudent even under the superintendence of the deputy?—No.

4792. Mr. *Locke.*] On what system did they work?—The long wall system; and of course the goaf was always within six feet of the face of the working.

4793. Was the shot let off on the face of the coal?—Yes.

4794. Within six feet of the goaf?—Yes. Perhaps for for a long time they had not seen much gas. When we registered the barometer that day, we found between the Wednesday night and the Thursday morning, that it had fallen three-quarters of an inch; and before the Thursday night it had fallen upwards of an inch, and a quarter of an inch more from Wednesday night.

4795. *Chairman.*] Who is the viewer of Monkwearmouth?—Mr. Elliott.

4796. Is he a man of great experience?—Yes.

4797. Have you seen Mr. Nicholas Wood's evidence with regard to the education of viewers, and persons who have the superintendence of collieries?—I have glanced at it.

4798. In your opinion, should steps be taken to establish mining schools in districts?—I think it is very desirable, for the more education we have among us the better.

4799. Even supposing the system which Mr. Nicholas Wood recommends were fully carried out, it would only be a prospective remedy, and would only be useful in time to come?—Yes.

4800. As an immediate remedy, it would not have any great effect?—No.

4801. As a prospective remedy, you think nothing is better than the establishment of schools to improve the education of the viewers?—I think that is very desirable indeed.

4802. Have you turned your attention to the question of coroners' juries?—I have thought of it, but I do not see that, in England, it could be materially altered.

4803. Are you of opinion that the persons who are now generally summoned to serve on coroners' juries are proper persons?—Sometimes they are not. You cannot always get good men to serve on coroners' juries, because, in a pit village, perhaps, there is no one besides the working class.

4804. It has been stated to this Committee that it is not proper to summon on juries the head blacksmith and people who are connected with the working of the pit; is that your opinion?—I think that no one who is connected with a colliery where an accident occurs ought to be on the jury.

4805. Mr. *Locke.*] Is it always very difficult, in other cases than accidents in coal mines, to obtain the best men as jurors to try such cases?—Yes, it is very difficult.

4806. *Chairman.*] You have stated that, in your experience, you do not find that the workmen in mines commit acts of great carelessness, so as to endanger their lives, and the lives of their fellow-workmen?—No; I think that, with very few exceptions, my men are exceedingly attentive and obedient.

4807. Is the law ever enforced in your district to punish men?—Yes; they are fined, and sometimes sent to prison.

4808. There is no difficulty in enforcing the law?—No.

4809. On that head you think there need be no improvement?—No.

4810. In your opinion, should fines be levied on the owners of collieries, if they neglect to put their mines in a safe state, and thereby endanger the lives of the

the workmen?—If the parties find there has been neglect, they can fall back on Lord Campbell's Act, and bring their action against the proprietor.

4811. Does not Lord Campbell's Act apply only to parties whose friends have either been killed, or who have themselves been injured or maimed by accidents which have occurred from acts of carelessness?—Yes.

4812. Mr. *Locke.*] You have been understood to state, that the proprietors of collieries would have no objection to be bound by rules and regulations which were laid down by practical men?—Certainly, they would not.

4813. They would object to be bound by compulsory powers put over them, and those powers placed in the hands of persons who, in their judgment, were not competent to carry them out?—Exactly. I can state a case which I think will show the hardship on the coalowner from such a state of things; for instance, at South Hetton, the Morton pit cost about 300,000 *l.*; and if the Inspector of Mines made an order that another pit should be sunk, it would cost in all probability 100,000 *l.* That would be a great hardship upon the owner of that colliery.

4814. It has been stated that, when a pit is sunk, the water having been got rid of, another pit could be sunk for a very small sum of money, and an estimate as low as 10 *l.* per fathom has been given as the price of sinking a pit?—That would not pay for the labour.

4815. In the case to which you have alluded, do you think that a pit of that kind could be sunk for anything like that price?—By no means; it would not pay for the labour of sinking; and, besides, there is all the tubbing, which costs perhaps 60 *l.* or 70 *l.* per fathom.

4816. Do you think that the case which the person who gave that testimony had in view, was perhaps a smaller colliery, where tubbing was not required, and where the ground was extremely favourable?—Yes; where no difficulty was contemplated.

4817. In the mines generally, in the north of England, you think that sum would be very inadequate to sink a shaft for any purpose?—It would not do a tenth part of it.

4818. *Chairman.*] Do you use the anemometer, and other scientific instruments, in your pits?—I have got an anemometer; but I always prefer, in measuring the quantity of air, to use the gunpowder.

4819. Why?—Because it is the simplest, and without any friction. In the anemometer, with so many wheels to be turned, there is a great deal of friction; and the full quantity of air which is going into the mine is not given.

4820. Do you approve of the use of scientific instruments?—Yes; I have a barometer placed at the bottom of my shaft, at Seaton Delaval, and also at South Hetton and Morton; it is registered three times a day, and the overmen, deputies, back overmen, and wastemen, examine them every day when they first go down the pit.

4821. Have you faith in the anemometer?—I think it is pretty correct; I have tried it several times with the gunpowder smoke; it entirely depends on the quantity of air; if there is a large quantity, it is more correct.

4822. Mr. *Locke.*] Did you ever make a comparative experiment in the same airways by the two systems, namely, the smoke and the anemometer?—Yes.

4823. Which gave the greatest result?—The smoke.

4824. Proving, therefore, the friction of the anemometer?—Yes.

4825. *Chairman.*] However excellent the anemometer may be, do you think it is a sufficient guide to an inspector who visits a mine once a month, or once a quarter, of the quantity of air which has been passing through the pit during time?—No; only at the time he is there.

4826. Do you think that an under viewer could tamper with such an instrument as the anemometer, and make it go faster than the actual ventilation justified?—He might make it go slower.

4827. Could he not, by contracting the space, make it go faster?—No; if he contracted the space, the inspector would take the size of the space where the anemometer was set, and get the quantity.

4828. Could he not contract the space when the inspector was away; and when the inspector came, might he not fancy that the air was travelling through a larger space where the anemometer was placed, than it actually did?—He might do that, but that would be the fault of the viewer.

4829. Mr. *Ingham.*] The smoke does not test the actual velocity of the air?—

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No. There is something in the smoke that I cannot make out; I think that some of it is destroyed before it gets to the end of the distance.

4830. *Chairman.*] Rather than put too much faith in scientific instruments, it would be better to pay more attention to the character, the responsibility, and attainments of your managers, viewers, under-viewers, and persons of that kind?—Yes; but I would also keep an eye on the increased size of the air passages. That is one of the great points.

4831. In your district are schools pretty general?—Yes; in all my places we have schools.

4832. How are your schools supported?—The coalowner finds the master and mistress, and gives them a certain salary, and the children pay 1 *d.* or 1½ *d.* a week.

4833. It has been stated before this Committee, that if the colliers themselves had some concern in the management of the schools, and had some control over the appointment of the master and mistress, they would have no objection to have a fixed amount stopped from their earnings; the stopping of that amount being enforced by law. In your opinion would that be a good system?—I think it would be a good thing; and, in corroboration of my opinion, I may state that every man at Seaton Delaval signed a paper, and presented it to me, that it might be done.

4834. Mr. *Ingham.*] What did they wish to have done?—That a good master and mistress should be appointed; that they should have their say in their appointment; and that they were quite willing that a certain sum per fortnight should be taken from their earnings to pay the master and mistress.

4835. Mr. *Mostyn.*] Does that feeling exist generally in the north?—I think perhaps not altogether, but I am only speaking of this as a case which has come under my own notice at Seaton Delaval.

4836. Mr. *Locke.*] Do you think that feeling is general in the north of England?—I think that no objection would be made to such a system; but I never knew an instance of it before.

4837. It was universal in your case?—Yes.

4838. May the Committee fairly assume, that as it was universal in your case, it would be generally acceptable in the neighbouring country?—I do not think the men would object to it.

4839. Mr *Mostyn.*] Even if it were made compulsory?—Even if it were made compulsory.

4840. *Chairman.*] Do you think that the attention of colliers is now more directed, than it used to be, to the subject of educating their children?—Yes, considerably.

4841. You think they are more aware of the importance of it?—Yes.

4842. Is their general character greatly improved?—It has very much improved since I first knew them.

4843. Did you ever have any communication with Mr. Jude, the secretary of the Miners' Association, at Newcastle?—I have seen him. He was down the Seaton Delaval pit, with me, about five weeks ago.

4844. Has he ever had occasion to represent to you any complaints from workmen?—No.

4845. If he did so, should you have any hesitation in ascertaining whether those complaints were well founded, and in correcting them if they were well founded?—They should be fully investigated, and if anything was wrong it should be put right.

4846. Would you take care, if you knew the names of the workmen lodging such complaints, that they should not be punished by a deputy or an inferior officer?—They should be protected; but I would rather prefer my men making complaints to myself.

4847. You have never found difficulty in your men making complaints to you?—No.

4848. You think it is possible that in all cases a really good and proper understanding may be kept up between the manager of a colliery and the workmen?—It ought to be so; and I think there is no difficulty in it, in any case.

4849. Mr. *Ingham.*] What number of men are employed in the Seaton Delaval colliery?—We have about 300 coal hewers, and there are the deputies and wastemen.

4850. How many altogether, on the surface and down the pit?—I think, men and boys, about 1,000.

4851. *Chairman.*]

4851. *Chairman.*] The Committee would suggest that Mr. Wood, yourself, and others of the principal viewers in the north of England, should meet together during the recess to consider what rules could be made generally applicable, to be enforced by law, for the inspectors?—I should be very happy to render my assistance.

4852. In framing such rules, it would be well to consult the workmen, or the secretaries of associations, to see the rules satisfied as much as possible the requirements of the workmen and of the owners of collieries?—Yes; and the inspectors ought also to be present.

4853. You would have no difficulty in getting the inspectors to attend?—I should think not.

4854. Will you direct your attention to that subject?—I will.

4855. Have you anything else to state to the Committee?—I have not.

LIST OF APPENDIX.

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Papers delivered in by N. Wood, Esq.:

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APPENDIX.

Appendix, No. 1.

PAPERS delivered in by *N. Wood*, Esq.

NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

EXPERIMENTS on the relative VALUE of the FURNACE and the STEAM JET, in the VENTILATION of COAL MINES, communicated to the North of England Institute of Mining Engineers, on Monday, 13th December 1852, and Friday, 4th February 1853. By *Nicholas Wood*, F.G.S., President of the Society. Appendix, No. 1.

THE COMPARATIVE MERITS OF FURNACE AND STEAM VENTILATION IN COAL MINES.

THE subject of the ventilation of coal mines has recently taken a great hold of public attention. According to the statements of the Government Inspectors of Coal Mines, the number of individuals who have lost their lives by explosions in coal mines since November 1850, amounted to the awful average of 250 persons annually.

The very statement of such a fearful fact sufficiently accounts for the excitement of the public, justifies the inquiries which Parliament has thought proper at various times to institute, for the purpose of ascertaining if it is practicable to devise any means to obviate, alleviate, or prevent the occurrence of such dreadful calamities, and calls loudly upon all those who are interested, either in the management of mines, in the success of mining operations, or from feelings of humanity, to exert the utmost of their endeavours and means in the promotion of such measures as may most effectually accomplish so desirable an object.

It would, however, be misleading the public if it is expected that an improved mode, or any improved modes of ventilation could alone accomplish such a *desideratum*, or could ensure perfect safety. It might lead to a false security, the dependence on which alone might produce the very evil which it is intended to remedy. Still the public have had it represented to them so assiduously, so strongly, and apparently so conclusively, that most if not all the explosions which occur are attributable to defective ventilation; that the time has arrived when the whole question must be gone into, in such a manner as to present to the public some conclusive data as to the causes of such accidents, the means which have been taken, or which are now in operation to afford security or safety, and also to investigate, in a sound, practical, and scientific manner, whether any and what measures can be devised to prevent the recurrence of such lamentable calamities.

I need not point out to my professional brethren, but I may be allowed to point out to those associated with us in promoting all that can in any way tend to the prevention of such accidents, and to the public in general, that the improvement of ventilation, or increasing the ventilating powers of a mine, is only one of the many requisites in the practice of coal mining which are necessary to ensure safety or security from explosions. There are a great many other operations, of almost, if not quite, of equal importance to a good ventilation to be attended to or carried into effect, to render a mine even comparatively safe; and therefore the entire subject is a most complicated one, and one which requires the utmost care and caution in its investigation and adoption.

There is no doubt that all those other requisites have been well considered, and have become the subject of investigation, research, and practical adoption by individual members of the institute, and we may hope that those researches, and the result of their practical experience, will be brought before the institution in such a manner as that the united practical knowledge of the institute will be made to bear upon their consideration and investigation, and that no exertions which are within the powers and capacity of the institution will be wanting to arrive at measures which may best accomplish the object it is so desirable should be attained.

Without, however, depreciating the importance of the other requisites necessary to complete the security of a coal mine, it is no doubt a first and important step to attain as

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powerful a ventilation as possible. And as I have already stated, so very important has this been considered by the public in general, and by almost all the non-professional writers on the subject, that an almost universal concurrence has been established, that the only *panacea* for the prevention of accidents in mines is ventilation.

This has been much fostered by the results of the labours of the several Committees of the Houses of Lords and Commons, who have invariably laid great and predominant stress on better and complete ventilation of the mines. And this feeling has been recently more intensely excited by the Report of the Committee of the House of Commons, which sat in the spring of 1852. That Committee stated, in allusion to the labours of all those who preceded them (viz. to the several Reports of the Lords and Commons, to the reports of the inspectors and others), that all their reports leaned to the conclusion, that "increased ventilation was the only true and secure means for the prevention of accidents." And the Committee themselves state, as their conclusion, "that a generally increased ventilation is the truest security against explosions."

The Committee further state, as their opinion, "that any system of ventilation depending on complicated machinery is unadvisable, since, under any disarrangement or fracture of its parts the ventilation is stopped, or becomes less efficient."

And this Committee, having received such evidence as appeared to them conclusive, reported as follows: "Your Committee are unanimously of opinion that the steam jet is the most powerful, and at the same time the least expensive method for the ventilation of mines." And (after alluding to the destruction of life by the "after-damp," in cases of explosion) they add, "Your Committee are unanimously of opinion, that the primary object should be to prevent the explosions themselves; and that if human means (as far as is known) can avail to prevent them, it is by the steam jet system, as applied by Mr. Foster; although even in such case it might be prudent, in a mine especially fiery, to add an inexpensive steam jet apparatus at the top of the downcast, as a means in reserve in case of explosion from neglect or otherwise."

Having been examined before that Committee, and having given evidence, and expressed an opinion that the relative merits of the powers of the furnace and of the steam jet, as producing ventilation of coal mines, had not been sufficiently tested, I stated to the Committee that I was then engaged in making preparations for testing their comparative merits, and that it was my intention to institute a set of experiments, to determine, if possible, their relative merits.

Considering that it was a proper subject of inquiry, or indeed, an inquiry incumbent upon some member of the profession, to conduct such a set of experiments as would, in a practical manner, determine the relative merits of what the Committee call the "rival powers," and having made such a pledge to the Committee, I have at the Hetton, Killingworth, and Tyne Main Collieries made a series of experiments to develope their relative powers, which I now have the honour to lay before the institution.

I may here, however, premise, that it is not altogether a question of rivalry between furnace power and the power of the steam jet; the question extends itself to whether the steam jet can be beneficially applied to the ventilation of coal mines, either as a substitute for the furnace, as an auxiliary to the furnace, or, if it can in any way be adopted to prevent or assist in preventing the recurrence of explosions in coal mines, or to render the mines more safe. It is in this point of view that I have placed the subject before me for investigation, and not as an advocate for or opponent of one system or the other; and I must leave to the institution and to the public in general to determine whether the investigation has been conducted in such a manner as to fairly, impartially, satisfactorily and conclusively test the relative merits of the two systems, both separately and in connexion with each other, and whether I am justified in the conclusions to which I have arrived. I can only add, that if I have failed, it has not arisen from a want of inclination or determination to conduct the investigation impartially and conclusively, but from a want of ability to do so.

With these observations, I shall now proceed to lay before you the result of my investigation. In the first place, however, it is necessary to state, that I found in the course of such investigation, and in the prosecution of the requisite experiments, that it was necessary, in order to test in a practical manner the relative merits of the two systems, to enter in the first place into the principles of each system in all their bearings, then to ascertain their relative practical effect of producing ventilation in mines. And to arrive at a satisfactory conclusion, I have found it also necessary to investigate and determine the resistance opposed to the moving power of each system in the practical operation of mine ventilation.

I shall therefore, first of all, enter upon a short investigation of the principles and laws which govern the moving power of the furnace, as a ventilating force; next, a similar investigation of the principles and moving power and laws which govern the action of the steam jet. I shall then enter into an investigation of the laws which govern, and the amount of the various resistances opposed to such moving forces, and which it is requisite to overcome in order to produce a certain standard of ventilation. I shall then give in detail the numerous experiments which I have found it necessary to make, in order to ascertain the practical effect of each system; and lastly, determine the practical result and efficiency of each system in the ventilation of coal mines.

The experiments have been made on mines almost as extensive as any in the kingdom, and in a manner and of a magnitude to test the practical effect of the two systems, as applied to ventilation on a large scale. I have, however, found the subject branch off into so many ramifications, which all required investigation, that I found my professional engagements

engagements would not allow me that time to pursue them, to such an extent, at least, as I could have wished. I shall, however, take the liberty of presenting to you what I have done, and which, I trust, will not be found without interest, if not conclusive on the subject. Other gentlemen, I find, are also engaged in similar investigations, and are making experiments in other collieries, on the comparative merits of the two systems, which will also be laid before the institution. Appendix, No.

When all these, and probably others which may arise out of the further investigation of this important subject, shall have been laid before you, I trust that the institute will be possessed of a mass of information on a subject of inquiry of infinite importance to the mining interest of the district, and, indeed, to the nation at large, out of which we may trust that something may be elicited which may alleviate, if not avert, some of those dreadful calamities which have so often produced such distress in the coal mining districts of the kingdom.

With these further observations, I shall now proceed to the investigation of the principles and powers of the furnace, as a means of producing ventilation of coal mines.

Description of Furnaces used in Ventilation.

The period when the furnace was first used as a means of ventilation of coal mines cannot be correctly traced. It is stated that Mr. Niewald, of Sweden, in the year 1740, and Mr. Jars, in 1760, both endeavoured to elucidate the art of ventilating of mines; the latter laying down principles and explaining natural ventilation (which it is said was then little understood), and suggested a small furnace at the top of the pit, with a chimney, to aid the natural ventilation.

This appears to have been the first mode adopted of producing artificial ventilation. The top of the upcast shaft was closed up, a chimney, hollow shaft, or tube (as it was called) was built at a little distance from the pit, to a height varying from 30 to 60 feet or upwards, according as a more or less powerful ventilation was required, with a covered passage between the top of the pit and the bottom of the tube. A large fire or furnace was placed in this drift or passage near the bottom of the tube, the rarifying power of which, together with the effect of the heated air in the shaft, produced the ventilation. A side drift, or covered passage, was also required for the purpose of obtaining access to the furnace, and into which were placed two doors, so that in passing to the furnace one of these should be constantly shut, in order to prevent the intrusion of the outer air to the heated air of the shaft.

Fig. 1, Plate I. represents a sketch of this mode of furnace ventilation. *A* the pit or shaft, *B* the covered way or drift, *C* the chimney or tube, and *F* the fire or furnace. *Vide* Plates, p. 176.

This description of furnace appears to have been used for a long period, as we find at some of the old collieries remains of the chimneys standing to this day. The last used in the neighbourhood of Newcastle was at the Felling Colliery, and which was in use when an explosion took place on the 26th of May 1812, by which 92 men and boys were killed.

It will be observed that this mode of ventilation could only be used where the upcast shaft was closed up, thus rendering it inapplicable for the drawing of coals.

This mode gave way to the application of the fire or furnace being placed at the bottom, or near the bottom of the upcast shaft, which, operating on the air in the entire length of the shaft, was so much the more efficient, as the depth of the shaft was greater than the height of the chimney or tube.

Figs. 3, 4, 5, 6 and 7, Plate I., represent modern furnaces, being a representation of the furnaces of Hetton Colliery, where the experiments hereinafter described were made, and which will be more particularly described when the experiments are given.

This description of furnace or furnaces are generally placed at a distance of 30 or 40 yards from the bottom of the pit, so that the flashes of flame, when fresh coals are put on, should not reach the shaft, or that the flame should be distributed or mixed with the air before it reaches the shaft. The drift for the passage of the air from the furnace to the shaft is always, especially in deep shafts, made to rise at an angle of 30 to 45 degrees. In more shallow shafts, it may be more advisable, if it can be done, to place the furnace as near the bottom of the shaft as possible, so that the greatest length of column of heated air should be obtained.

The above may be taken as the general form of furnace used in furnace ventilation; they may be varied in width, the form of the arch, and in some other respects, but the mode in which the furnace is made to operate is in all the same, viz., to pass the air of the mine over the fire, and so to raise it to as high a temperature as possible.

Principles of Action of the Furnace.

The mode of application of the furnace is therefore very apparent, but as I shall have, in order to compare its relative merits with the steam jet, to go very minutely into, not only its principle of action, but its practical effect in producing ventilation, it will be requisite that I should explain in detail the manner in which the furnace acts in the production of a current of air around the workings of a coal mine.

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Supposing two shafts, *A* and *B*, Fig. 2, Plate I., of equal depth, with a communication between them at the bottom, by a drift or passage *C*. If these two shafts and the drift *C* were filled with air of precisely the same temperature and density, the air would remain stagnant, there would be no current. But suppose by any means heat is imparted to the air in one of them, say in *B*, then the equilibrium will be destroyed; the effect of the heat in *B* will be to expand the air in that shaft, to render it specifically lighter than the column in *A*, and consequently, if there is an open passage at *C*, the heavier column of *A* pressing upon the lighter column of *B* will force it upwards, and produce a current of air along the passage *C*, in the direction of the arrow.

And if the heat imparted to the air in the shaft *B* be continuously kept up by, for instance, a fire or furnace placed at *F*, over which the air from *A* should pass, then a continuous current of air will be kept up, down the downcast *A*, along the passage *C*, and up the upcast *B*.

And, if we suppose, instead of the drift or passage *C* being a drift simply between the bottom of the two shafts, that it is extended so as to form a variety of drifts, or, in fact to comprise the workings of a colliery, then we have an illustration or representation of the whole action of the furnace in producing the ventilation of a coal mine.

This, then, is the entire principle of action of "furnace ventilation;" a fire or furnace, or in some cases two or three furnaces, are placed at or near the bottom of the upcast shaft, over which the air that passes down the downcast shaft and around the workings is conveyed, and which, being heated by such furnace or furnaces, passes into the upcast shaft, and thus constitutes a column of air of less density than the column in the downcast shaft; and the column of heavy air in the downcast pressing, through the medium of the column of air, around the workings upon the lighter column of the upcast, so produces a continuous current of air through the mine, of greater or less velocity, as the column of air in the shaft *B* is of less or greater specific weight than the column of air in the shaft *A*.

It is the same thing, and is, I daresay, a more popular definition to say, that the heat of the furnace *F* acting upon the air passing over it into the shaft *B*, renders such air specifically lighter; and that the tendency in columns of air heated above that with which it is in contact, to rise, creates an upward current of air in the shaft *B;* and that the current of more dense air passing to the furnace rushes in to fill the vacuum which would otherwise be created by the upward motion of the heated air, and thus a continuous current is produced around the workings and down the shaft *A*. Whatever language, however, we make use of to describe the mode of action, it is quite clear that the motion of the current of air around the workings is produced by the difference of weight between the two columns *A* and *B*, and that in the ratio in which we increase this disparity, or make the one heavier than the other, so much the more power do we obtain to produce ventilation.

Before proceeding further into the principles of furnace ventilation, it may be useful to allude to natural ventilation, as it bears to an important extent, in some cases, upon the subject of our investigations. It is well known that as we descend into the earth by a shaft or pit the temperature increases, and it increases in some ratio with the depth, and many experiments have been made in deep mines to determine the rate of increase. We also know that the superficies of a mine in which workings have been made also give out heat, and that the air, after it has passed through a mine, is of a higher temperature than when it entered. Such heat acting upon the air of the mine rarifies it, and passing into the upcast shaft, presents a column of air specifically lighter than that in the downcast shaft, and thus a continual current of air is produced down the downcast, around the workings, and up the upcast shaft, without the aid of artificial heat or of a furnace, and this constitutes what is correctly called natural ventilation.

Natural Ventilation.

I shall give two cases of this kind, which have come under my observation, and which it may be useful to communicate; the first, a case where the workings were very limited, and the other where the workings were more extensive. The first is that of the deep winning at Seaton, near Seaham. The shaft is 260 fathoms, or 1,560 feet in depth to the Hutton Seam.

The shaft is 14 feet in diameter, with an air-tight brattice dividing it into two equal divisions from the top to the bottom. After the pit had been sunk, and a communication in the coal made around the walls or pillars left for the support of the shaft, the pit was not worked for upwards of two years, and during that time only two men were in the mine for about eight hours in each day. There was, therefore, no artificial heat, especially when the men where out of the pit. I made an experiment at this pit, the details of which are given in the following Table, No. 1, by which it will be seen that a quantity of heat evolved in the drift, along which the air passed, raised the temperature of a current of air of 7,000 cubic feet per minute $3\frac{1}{2}^{o}$. The distance which the current of air traversed from the bottom of the downcast to the bottom of the upcast was 3,036 feet. The superficies of surface to which air was exposed, and which gave out the heat, cannot be correctly ascertained, from the irregularities in the area of the passages, but it may be taken at about an average of 20 feet in each foot of drift, or in the aggregate of 60,720 square feet.

TABLE

Appendix, No. 1.

TABLE No. I.

EXPERIMENTS made at the SEATON PIT on NATURAL VENTILATION; Depth of Pit, 260 fathoms, or 1,560 feet; Diameter of Pit, 14 feet, divided equally by a Timber Brattice, air-tight from Top to Bottom.

Depth from Top of Pit.	TEMPERATURE.		Difference of Temperature.
	Downcast.	Upcast.	
Feet.	*Degs. Far.*	*Degs. Far.*	*Degs. Far.*
Bank - -	44°	46°	2°
120	44°	47·5	3·5
240	43·75	48°	4·25
360	44·25	48°	3·75
480	44·25	48°	3·75
600	44·75	48·25	3·5
720	45·25	49°	3·75
840	45·25	49°	3·75
960	45·5	49°	3·5
1,080	46·5	49·25	2·75
1,200	47·75	51°	3·25
1,320	48·5	51·75	3·25
1,440	49°	52°	3°
1,560	49·5	62·5	3°
Average - -	46°	49·5	3·5

Quantity of air, 7,002 cubic feet per minute. Length of air courses, 3,036 feet, the air being split on each side of the shaft. Average area of air courses, 24 square feet, with some small contractions.

The next case of natural ventilation is shown in the experiments at Tyne Main Colliery. To obtain as accurately as possible the power of the steam-jet apart from the aid of any artificial ventilation the furnaces were put out, and they were kept out until the temperature of air in the upcast shaft was precisely the same as that of the air entering the bottom of the shaft, after passing through the mine.

On referring to Tables XV. and XVI., it will be seen that in both the experiments on the 14th and 15th January respectively, the temperature in the return air, or air passing to the bottom of the upcast shaft, after having passed through all the workings, was 63°, and that in the upcast shaft at 10 fathoms from the surface, the temperature was 62° in the first, and 63°, 64°, 65°, in the second experiment. The temperature of the air at the bottom of the downcast, or before entering the workings, was in the former case 42°, and in the latter 43°, so that the heat communicated to the air in its passage through the workings of the mine was respectively 20° and 21°, upon a quantity of air equal to upwards of 36,000 cubic feet per minute.

The following Table will show the results of these experiments.

TABLE No. II.

Date of Experiment.	Depth of Shaft in Feet.	TEMPERATURES.					Quantity of Air in Cubic Feet per Minute.
		Bank.	Bottom of Downcast.	Return Air.	From Surface in Upcast Shaft.		
					60 Feet.	390 Feet.	
1853:							
Jan. 14th -	672	36°	42°	63°	62°	61°	34·955
„ 15th -	„	43°	45°	63°	64°	62°	36·564
„ „ -	„	43°	45°	63°	65°	61°	37·182

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It is extremely difficult to ascertain the precise extent of the superficies which produced the above result. The entire workings of the colliery embrace an extent of about 288 acres. In about 50 acres, the whole of the coal is exhausted, and comprises what is called goaf; the current of air only sweeping around its edges, and receiving in its passage the heat emanating from the goaf. The remainder of the workings has been worked in the pillar and stall method, the excavated portion comprising about 56 acres, the remainder, 102 acres, comprising the coal left. There is, therefore, excavated 106 acres, and standing in pillars 102 acres, each pillar being generally about 30 yards by 11 yards, and the seam is 5 feet 6 inches in height on the average.

The heat thus given out and communicated to the air in its passage through a coal mine is necessary to be taken into account in this investigation, as of itself it produces ventilation of a certain amount, independently of any artificial means, but which it certainly materially assists. The quantity of heat evolved in so small an extent of workings as that of the first experiment we find to be considerable, and, in that of the second, very much more so. In mines of greater extent it is, of course, still greater, in proportion indeed to the extent; and when we also take into consideration the heat produced by the number of men, boys, horses and ponies, and by the gases given out in an extensive pit, we shall find that this amount of heat is considerable, and that it has a material effect in aiding artificial ventilation, especially in deep mines.

It is, however, necessary to state, that this result arises only when the temperature of the atmosphere is very low, and when, consequently, the temperature of the air entering the workings of the mine is also very low; in summer the result is different. We find from experience, that the temperature of the return air, after it has passed through all the workings of the mine, is nearly the same in summer and winter, though the temperature of the air entering the workings varies more than 20°, absorbing almost, if not quite, the whole of the temperature producing "natural ventilation." In winter therefore, we have the assistance of say 20° to assist the artificial ventilating power of the mine, and in summer nothing at all; and so in proportion as the temperature of the atmosphere varies.

We are thus enabled to account for the sluggish ventilation of the mines in hot and sultry weather, and this also shows the necessity at such periods of increasing the artificial ventilating powers of the mines. The increased power required, as exhibited in the above case, is that of heating 36,000 cubic feet of air 20°, or 720,000 cubic feet of air 1° per minute. In furnace power, we find by the experiment, Table XII., that 1lb. of coal consumed per minute heated 11,066 cubic feet per minute of air 62°, or 686,092 cubic feet 1°; we therefore require about 1lb. of coal per minute extra to compensate for the loss of natural ventilation, when the temperature of the air in the downcast, and in the return from the workings, is the same. But in the case of the steam jet, we find the increase over the natural ventilation only about 12,500 cubic feet per minute, little more than one-third of the amount of natural ventilation, though such a result was produced by the evaporation of 1·82 cubic feet of water per minute into steam of 40 lbs. pressure per square inch, and applied at the top of the pit in 61 jets $\frac{3}{16}$ ths of an inch in diameter.

Before entering upon the ventilating powers of the furnace, I may also premise that I have in the course of my investigations endeavoured to conduct them in as purely a practical manner as possible, so that the results should exhibit the practical working effect of the two systems on collieries of sufficient magnitude to set the matter at rest, or leave no doubt upon the subject; I have therefore abstained from theoretical disquisitions almost entirely; only so far, certainly, as I have found it necessary to elucidate the subject and assist in arriving at a correct conclusion.

I shall now endeavour to determine and lay down some practical data of the power of the furnace in producing ventilation.

We have seen that the power of the furnace consists in the difference of density of the two shafts, the downcast *A*, and the upcast *B*. If the temperature of *A* is known, then we can correctly ascertain the weight of its column, the depth being known; and in the same manner the temperature and depth of *B* being also known, we can ascertain the weight of its column, and we can take the weight of each in lbs. avoirdupois per square foot of area of the shaft.

I have adopted this mode of investigating the powers of the furnace in lbs. pressure per square foot of area of shaft, as I shall in like manner investigate the powers of the steam jet in lbs. pressure per square foot of area; and having done so in both cases, I shall then from the same data determine their relative practical effect.

Reverting back to the furnace, having the weight of the column *A* and the weight of the column *B*, then the power to produce motion is well known, being the same as that of two weights of different magnitudes, viz., of the weight *A* (represented by the weight in lbs. of the column *A*), and the weight *B* (represented by the weight in lbs. of the column *B*), passing over a pulley, the theoretic expression of which is well known, the weight *A* being the moving power, and the weight *B* being the resistance opposed to the free motion of *A*; friction, resistance of the opposing medium of air, &c., being set aside in the theoretic investigation of the effect of two such forces. We may, however, include these even in the theoretic consideration of the subject. We can represent the friction, resistance of the air, and any other opposing medium, by an additional weight *C*, to be added to *B*; and hence we have $A =$ the moving power, and $B + C =$ the resistance. And then, by the well-known principles of dynamics, having the laws which govern the weight and motion

motion of *B* and *C*, we can determine the expression of power requisite to produce a given effect.

It is precisely in this way I propose to deal with the practical investigation of the furnace and steam jet. I take the weight of the column of air in the downcast shaft *A* in lbs. per square foot of area of the shaft or pit, as the moving power of the furnace; and in like manner, the force or pressure per square foot of area of the shaft, as the moving power A' of the steam jet. Then I take the weight of the column *B* of the upcast as one part of the resistance, and the friction resistance, or drag of the air in its passage around the workings of the mine, as the other part of *C*; being together the resistances opposed to the power *A* of the furnace, in the one case, and to the power A' of the jet in the other.

If the respective values of *A* A' and *B C* were known, we could have determined theoretically the merits of the two systems without having recourse to expensive and tedious experiments; but it is precisely that we have not those values, and that we cannot obtain the practical operative effect of them, without a series of experiments, on a sufficiently extensive scale and magnitude to obtain correct practical data of their values, that the matter has remained so long in doubt, and that I have found it necessary to pursue the subject so minutely, and to carry out such extensive experiments.

I trust, however, that the experiments which I shall lay before you, will not only determine the requisite data, but that they will furnish data going far towards establishing practical results in other branches of coal mine ventilation.

I shall now therefore proceed, in the first place, to determine the power *A* and the resistance *B* of furnace ventilation, which we find represented by the weight of the air of the two columns *A* and *B*. These, of course, are determined by the ascertained weight of air at the different degrees of temperature in the respective shafts.

The weight of air at different degrees of temperature, as determined by Dr. Dalton and Gay Lussac, was long considered as correct. They found that atmospheric air, the barometer being at 30 inches of mercury, expanded $\frac{1}{480}$th part of its volume, for each degree of temperature (Fahrenheit) from 32° upwards, or $\frac{1}{448}$th from unity.

The more recent and extensive experiments of Magnus and Regnault has, however, determined the rate of expansion to be the $\frac{1}{491}$th part from 32°, or the $\frac{1}{459}$th part from unity. And they found, which is of great importance in this investigation (as indeed did Dr. Dalton also), that the degree of expansion was in the direct ratio of the degree of heat imparted.

The volume at 1° being 459, the volume at any other temperature, *t*, will be $459 + t$. Hence, to find the volume of any column of air at any given degree of temperature, we have only to take the volume at unity at 459, and add the number of degrees of temperature of any column of air; the sum will be the volume of that column of air. Thus, the volume at 60° will be $459 + 60 = 519$, and the volume at 180° will be $459 + 180 = 639$. Therefore, if the air in the columns *A* and *B* are respectively 60° and 180°, then the volume of the columns will be respectively 519 and 639.

Dr. Dalton has given a Table of the expansion of air, from 32° to 212°, of which the following is a copy:—

TABLE of the Expansion of Air by Heat, by Dr. *Dalton*.

FAHR.	VOLUME.	FAHR.	VOLUME.
32°	1,000	130°	1,215
40	1,021	140	1,235
50	1,043	150	1,255
60	1,066	160	1,275
70	1,089	170	1,295
80	1,110	180	1,315
90	1,132	190	1,334
100	1,152	200	1,354
110	1,173	210	1,372
120	1,194	212	1,376

And the volume for any other temperature, *t*, will be $1000 \times \frac{448 + 32°}{448 + t}$.

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Professor Hann, in his evidence before the Committee of the House of Commons, 1852, says, " the experimental results of Magnus and Regnault consider the expansion of air in being heated from t to t' as $1 - \frac{459 + t}{459 + t'}$ expressed in volume t, the original volume being taken as unity."

This expression makes the degree of expansion in the direct ratio of the temperature, and the following Table will show the expansion of air at the different degrees of temperature :—

TABLE of the Expansion of Air by Heat, by *Magnus* and *Regnault.*

FAHR.	VOLUME.	FAHR.	VOLUME.
32°	10,000	130	11,996
40	10,164	140	12,199
50	10,366	150	12,403
60	10,570	160	12,606
70	10,773	170	12,810
80	10,977	180	13,014
90	11,181	190	13,218
100	11,385	200	13,421
110	11,588	210	13,625
120	11,792	212	13,666

And the volume of any other temperature, t, will be $1000 + \frac{459 + 32°}{459 + t.}$

The difference between the two tables, it will be seen, is not of much consequence, in a practical point of view; but they both show, what is very important in the matter under consideration, that the expansion of air is in the direct ratio of the degree of heat imparted to it. And Mr. Tredgold, in his work on Warming and Ventilating Buildings adopts the same result. He says, p. 26, " If you would ascertain the quantity of fuel that would heat a cubic foot of air 1°, then the specific heat of water being 1, that of an equal bulk of air is 0·00035, or $\frac{1}{2850}$ (see Art. 217, Table II.); and if the quantity of fuel that will heat a cubic foot of water 1° be multiplied by 0·00035, the product will be the quantity of fuel that will heat a cubic foot of air 1°, and 20 times that quantity will heat it 20°, 30 times will heat 30°, and so on for any other temperature."

I shall now ascertain the relative weights of the two columns *A* and *B*. Mr. Tredgold, in the work above alluded to, assumes the weight of a cubic foot of air at the temperature of 60°, barometer 30 inches, at 527 grains troy, taken from Dr. Thompson's Specific Gravity of Gases, System of Chemistry, Vol. III. But the more recent experiments of Dr. Prout makes the weight of 100 cubic inches 31·0117 grains, at the same temperature and barometrical pressure.

As Professor Hann has adopted this latter standard, I shall do the same, and consequently we have only to find the number of cubic inches of air in any shaft, and the temperature, and we have the weight in grains troy in any column of air; the weight of air being, as above stated, inversely as its bulk.

As it will, however, be more convenient in our further investigations, to take as a standard the weight or pressure in lbs. avoirdupois for each foot of surface, it is easy to convert troy into avoidupois weight. We have, therefore, 31·0117 × 1728 ÷ 7000 × 100 = ·096376 lbs. avoirdupois, as the weight of a cubic foot of air at 60°, and 30 inches barometric pressure. And the following Table will show the weight of different columns of air in lbs. avoirdupois, at different degress of temperature, in shafts of different depths.

TABLE

TABLE III.

TABLE of the PRESSURE of the AIR in Lbs. Avoirdupois per Square Foot of Surface or Area, of Shafts of different Depths, and subjected to different Degrees of Temperature.

TEMPERATURE.	DEPTH OF SHAFTS, IN FEET.																	
	120.	180.	240.	300.	360.	420.	480.	540.	600.	660.	720.	780.	840.	900.	960.	1,020.	1,080.	1,140.	1,200.
°	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
32	9·710	14·565	19·421	24·276	29·131	33·986	38·842	43·697	48·552	53·407	58·262	63·118	67·973	72·828	77·683	82·538	87·394	92·249	97·104
40	9·555	14·332	19·109	23·887	28·664	33·442	38·219	42·996	47·774	52·551	57·328	62·106	66·883	71·661	76·438	81·215	85·993	90·770	95·548
50	9·367	14·051	18·734	23·417	28·101	32·784	37·468	42·152	46·835	51·519	56·202	60·886	65·569	70·252	74·936	79·620	84·303	88·987	93·670
60	9·187	13·780	18·373	22·966	27·560	32·153	36·746	41·339	45·933	50·526	55·119	59·712	64·306	68·899	73·492	78·085	82·679	87·272	91·865
70	9·013	13·519	18·026	22·532	27·039	31·545	36·051	40·558	45·064	49·571	54·077	58·584	63·090	67·597	72·103	76·609	81·116	85·622	90·129
80	8·846	13·268	17·691	22·114	26·537	30·960	35·383	39·806	44·228	48·651	53·074	57·497	61·920	66·343	70·765	75·188	79·611	84·034	88·457
90	8·684	13·027	17·369	21·711	26·054	30·396	34·738	39·080	43·423	47·765	52·107	56·449	60·792	65·134	69·476	73·818	78·161	82·503	86·845
100	8·529	12·794	17·058	21·323	25·587	29·852	34·117	38·381	42·646	46·911	51·175	55.440	59·704	63·969	68·233	72·498	76·763	81·027	85·292
110	8·379	12·569	16·758	20·948	25·138	29·327	33·517	37·707	41·896	46·086	50·276	54·465	58·655	62·845	67·034	71·224	75·414	79·603	83·793
120	8·235	12·352	16·469	20·586	24·704	28·821	32·938	37·055	41·173	45·290	49·407	53·525	57·642	61·759	65·877	69·994	74·111	78·228	82·346
130	8·095	12·142	16·189	20·237	24·284	28·332	32·379	36·426	40·474	44·521	48·569	52·616	56·663	60·711	64·758	68·805	72·853	76·900	80·948
140	7·959	11·939	15·919	19·899	23·879	27·859	31·838	35·818	39·798	43·778	47·758	51·738	55·717	59·697	63·677	67·657	71·637	75·616	79·596
150	7·829	11·743	15·658	19·572	23·487	27·401	31·316	35·230	39·145	43·059	46·973	50·888	54·802	58·717	62·631	66·546	70·460	74·375	78·289
160	7·702	11·554	15·405	19·256	23·107	26·958	30·810	34·661	38·512	42·363	46·215	50·066	53·917	57·768	61·619	65·471	69·322	73·173	77·024
170	7·580	11·370	15·160	18·950	22·740	26·530	30·320	34·110	37·900	41·690	45·480	49·270	53·060	56·850	60·640	64·430	68·220	72·010	75·800
180	7·461	11·192	14·923	18·653	22·384	26·115	29·845	33·576	37·307	41·037	44·768	48·499	52·229	55·960	59·690	63·421	67·152	70·882	74·614
190	7·346	11·020	14·693	18·366	22·039	25·712	29·386	33·059	36·732	40·405	44·078	47·752	51·425	55·098	58·771	62·444	66·117	69·791	73·464
200	7·235	10·852	14·470	18·087	21·705	25·322	28·940	32·557	36·175	39·792	43·410	47·027	50·644	54·262	57·879	61·497	65·114	68·732	72·349
210	7·127	10·690	14·253	17·817	21·380	24·944	28·507	32·070	35·634	39·197	42·761	46·324	49·887	53·451	57·014	60·577	64·141	67·704	71·268
212	7·106	10·658	14·211	17·764	21·317	24·869	28·422	31·975	35·527	39·080	42·633	46·186	49·739	53·291	56·844	60·397	63·949	67·503	7·1055

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The foregoing Table shows the pressure per square foot of area of the shaft, but the amount of ventilating power depends upon the area of the shaft, a shaft of 100 feet area being double the power of that of a shaft of 50 feet area, and a shaft of 150 feet area treble that of a shaft of 50 feet area. Having the mean temperatures of the upcast and downcast shafts, we have only to multiply the difference between the respective pressures per square foot of the two shafts, as shown in the preceding Table, by the area of the shaft, to ascertain the total amount of power, in lbs. avoirdupois, of any shaft. And if we require that to be expressed by horses' power, we have only to multiply that by the velocity of the air in feet per minute, and divide the sum by 33,000 feet, and we have the number of horses' power of ventilating force.

The above Table likewise shows the weight or pressure per square foot of area of shafts of different depths and different degrees of temperature, and enables us to ascertain the motive power A in shafts of the depths shown in the Table, when the mean temperature of the air in the downcast shaft is given. And it also shows the resistance or weight B of the air in the upcast shaft, opposed to the motion or moving power A of the air in the downcast, when the mean temperature of the air in the upcast is given.

Thus, suppose the mean temperature of air in a downcast pit 900 feet in depth to be 50°, then the motive power A is 70·252 lbs. per square foot of area of shaft. And if the mean temperature of the upcast B be 180°, then the resistance B of the weight of the column is 55·96 lbs. per square foot of area. Consequently the difference, 21·262 lbs. per square foot of area of shaft, represents the power applicable to overcome the resistance or drag of the air of the mine C, and produce a current of air which will fill up, or produce the dynamical equilibrium of the system, and which we have denoted by C.

We shall afterwards go into an investigation of the amount, and principles which govern the resistance or variety of resistances, which represent C, and this we shall find to be the most difficult part of the undertaking, comprising, as it does, all the complication of the obstructions opposed to the moving or ventilating power of the mine, whether that power be the furnace or the steam jet. Previously, however, to entering upon this part of the subject, it is requisite to notice a qualification in the power of the furnace in the ventilation of mines, which was raised during the investigation before the Committee of the House of Commons, in 1852, and which has been termed the "furnace limit."

It is rather inexplicable how this outcry should have been raised as against the furnace, without applying the same limit to the steam jet; as in the list of definitions and technical explanations in the Report of the Committee, the principles of action of the furnace and the resistance or drag of the air are correctly stated, except only as regards the "vena contracta," which is scarcely separable from the drag or resistance of the air.

It is there stated, as has been demonstrated by the preceding inquiries, that the power of the furnace is in the direct ratio, or arithmetical ratio, of the heat employed; no limit is pretended to be assigned to this power. Professor Hann himself gives the expansion of air, and consequently the power of the furnace, as equal to $1-\frac{459+t}{459+t'}$ t being the temperature of the downcast, and t' the temperature of the upcast; no limit is there given; and the experiments of Magnus and Regnault, though carried beyond the temperature practically in use in coal mine ventilation, showed that the ratio of the expansion of the air, and consequently the power of the furnace, was in the direct ratio of the increase of temperature.

It is true, as stated by Professor Hann, and adopted in the Report, that the resistance or drag of the air increases in a geometrical ratio, and that consequently there is, if not a theoretical, a practical limit to the ventilating power. But it ought to have been stated that this limit was equally applicable to whatever power was employed, unless that power increased, or is made to increase, in any other than a direct or arithmetical ratio; that it was equally applicable to the steam jet and the furnace; and that, in fact, it is the resistance, and not the power, which presents a practical limit to the amount of ventilation; and that it operates, as will hereafter be shown, to produce a practical limit to the power of the steam jet, as well as to that of the furnace.

Steam Jet.

The steam jet was first proposed as a ventilating power by Mr. Goldsworthy Gurney, in 1835, to a "Committee of the House of Commons on Accidents in Coal Mines."

His proposition to the Committee was, "a common boiler, furnished with a small tube, leading to the shaft, and pointing either up or down, as you desire the current to be driven, placed in a cylinder, the size of which must be governed by the quantity of steam used, or the quantity of current you intend to make. A very small jet of steam, at 60 lbs. to the inch, of about the size of a goose quill, will dislodge 350,000 cubic feet of air in an hour."

Again, in 1839, Mr. Gurney proposed to the South Shields Committee steam jets as a ventilating power, and sent drawings of the mode of applying the jets, which may be seen in their Transactions. Mr. Gurney then proposed that the boiler should be placed at the top of the pit, and the jets placed within it, about 20 or 30 feet down. And he says, "16 jets of $\frac{5}{16}$ths area, fed by steam of 40 lbs. per square inch, placed not less than 30 feet deep in the upcast, and equally divided through its sectional area, would produce a current

current of air, at the rate of 20 miles per hour, in a shaft 41 feet area, or 72,160 cubic feet per minute."

In 1849, Mr. Gurney again brought forward, before a Committee of the House of Lords, the steam jet; and lastly, in 1852, before a Committee of the House of Commons. With regard to the mode of applying the jet, Mr. Gurney, in answer to Question 433, Lords' Committee, 1849, "Is it desirable to place them near the surface, or near the bottom?" said, "Save the rarefaction, and the little power given out by the heat of the steam, in the shape of heat, and lightening the column, it does not matter where it is placed; it is not worth consideration." And in answer to Question 434, says, "It is not worth calculation." And he mentions an experiment at Seaton Delaval, making the quantity of air due to the rarefaction of the steam only 6,000 cubic feet per minute, the quantity of the steam jet being 33,000. He therefore assumes the ratio to be as 6 is to 33.

Notwithstanding the very flattering estimate of the powers of the steam jet, it does not appear that it was used at any of the collieries in this district until Mr. Forster adopted it, at the Seaton Delaval Colliery, in 1849, and, since then, it has been tried in some other collieries.

It has always appeared to me, that great part of the difference of opinion which has arisen as to the utility and efficiency of the steam jet has been occasioned from a clear distinction not having been made between the effect arising from the rarefaction of the air in the upcast shaft, by the heat of the engine fires, and by the heat given out by the steam (when the boilers are placed at the bottom of the pit), and the mechanical effect, or propulsive power, of the steam jet, as a moving force, in producing ventilation. It is true, Mr. Gurney attributes little or no effect to these aids, which, as previously noticed, he says are "not worth consideration," but attributes almost the entire power to the steam jet, as a propulsive force.

We shall not, however, be able thoroughly to estimate the power and efficiency of the steam jet unless we separate and determine by experiment, or in some other conclusive manner, what is due to each of the mechanical forces which contribute to form the entire power of the jet as a means of ventilation, in the different modes in which it has been or may be applied.

In order to accomplish these we shall have to consider separately, and subject to experiment:—

1st. The effect of the engine fires as regards rarefaction in the upcast shaft, when the boilers and jets are placed at the bottom of the pit.

2d. The effect of the rarefaction, and of the column of steam in the upcast shaft, when the jets are placed at the bottom of the pit, whether the steam is obtained from boilers at the bottom of the pit or is conveyed by pipes from boilers placed on the surface.

3d. The mechanical effect of the jets alone, as a propulsive force, to produce ventilation.

In the consideration of the first of these little explanation is required. If a fire is employed to pass underneath and around a boiler, to convert water into steam (apart from the consideration of the effect of that portion of the heat communicated to the steam, and again given out in its passage up the shaft, which comes under the second head of the inquiries), the surplus heat, passing into the shaft, acts upon the air in the upcast shaft in precisely the same manner, so far as regards the quantity of heat so communicated, as if such heat proceeded from a furnace; viz., by rarefying the air in the shaft, and producing an amount of ventilation corresponding with the quantity of heat so passing off.

It is, however, worthy of remark, and it is a circumstance of some importance in this inquiry, that a considerable diminution of effect is sustained if such fires are of the ordinary description; the combustion of the coal in the engine fires is not near so perfect as when the coal is consumed by a furnace. In the former case, the air is made to pass entirely through the grate bars, and through the fire, driving off a good deal of the volatile and combustible matter of the fire unconsumed; whereas, in the furnace, the air passes over the fire with great velocity, and the combustible matter is thus again thrown upon the fire, and is almost entirely consumed; indeed, in a well-worked furnace, the combustion is almost perfect.

This is well known to the profession, in upcast shafts, with engine-fires at the bottom, volumes of smoke are almost continually issuing; whereas, in furnace ventilation alone, there is little or no smoke emitted. This is not a simple question of comparative consumption of coal to produce the same effect, as the smoke from the engine fires adds to the weight of the column of air in the shaft, and so tends also to diminish the effect of the rarefaction. The experiments which will hereafter be given will prove this in a very conclusive manner.

In the consideration of the second set of inquiries, that of the effect of the steam passing up the shaft, also requires consideration. It operates, first of all, in increasing the temperature, and by the rarefaction of such heat, adds to the ventilating power. We have likewise to take into consideration the weight of the column of steam, compared with the weight of a column of air of the same temperature. And we have to take into consideration that property of steam and air, in contact with each other, to combine mechanically, and present a united bulk different from that of the simple addition of the two volumes. I have however previously stated, that it was my intention in this paper to deal with this investigation in a purely practical manner. I shall therefore simply confine myself to a statement of the

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theoretical result of the above questions, as deduced by the most modern inquirers, without going more into detail than is absolutely necessary to illustrate the subject.

The effect of the heat of the steam upon the column of air in the shaft will be the same as that of a similar quantity of heat communicated in any other way, except only as modified by the weight of the column of steam, in the first instance, and still further modified by the properties of air and steam when mixed.

According to the specific gravity of steam, as given by Dr. Thompson, it appears that a cubic foot of steam at 60° weighs 329·4 grains, when the barometrical pressure is 30 inches, and if f be any other pressure, we have—as $30 : f :: \frac{329{\cdot}4\,f}{30} = 10{\cdot}98\,f$ = the weight of a cubic foot of steam, at the force f, and temperature of 60°. Let t be the temperature at the force f, and let $t' = 60°$. Then, as previously shown, $\frac{459+t}{459+t'}$ = the bulk at the temperature t, supposing the bulk at 60° to be one cubic foot. Now, the densities being inversely as the spaces which the vapour occupies, we have $\frac{459+t}{459+t'} : 1 :: 10{\cdot}98\,f : \frac{5698{\cdot}6\,f}{459+t}$ = the weight of a cubic foot of vapour in grains, at the temperature t, and force f.

It has been ascertained that gaseous fluids, which do not chemically combine, mix together without condensation when the pressure is unaltered; and that, when they are saturated, a cubic foot of air absorbs exactly a cubic foot of steam, as it would exist in a vacuum at the same temperature. (*See* Gen. Roy's Experiments, Quarterly Journal of Science, vol. xiii., p. 82; or Daniell's Meteorological Essays, p. 174.

If the bulk of air be a, at the temperature t, and f the force of the vapour at the same temperature, and p the pressure of the atmosphere, then, since the bulk a of the air mixes with an equal bulk a of the steam at the pressure f, the bulk of the steam at the pressure p will be—as $p : f :: a : \frac{f\,a}{p}$ And the bulk of the whole, after mixture, will be—

$$a + \frac{f\,a}{p} = \frac{a\,(h+f)}{p}$$

(*See* Tredgold on Warming and Ventilating Buildings, p. 291).

These will be useful when we shall have to estimate what practical results can be obtained in other cases from the data resulting from the present experiments.

The next consideration is the mechanical effect of the jet of steam as a propulsive force. I have already noticed the mode in which Mr. Gurney proposed to apply the jet, either at the bottom or the top of the upcast shaft; the steam from a boiler, or more than one boiler, being made to pass through small apertures, and so produce a jet of steam issuing out of each of such apertures at a very rapid velocity, and acting on the air "by impulse, or *vis a tergo*," as Mr. Gurney expresses it, "driving the whole column of air up the shaft before it."

Mr. Longridge, in a paper read before the Institute of Mining Engineers, explains the action of the jet as "that of the friction of the steam rushing through the air with great velocity, and carrying it along with it." Whether it be the one or the other, or a combination of both, or a partial vacuum, created by the rapid expansion of the steam, into which the air rushes, and in which manner it is carried along with it, and also, probably, that property of steam to mix with the air, I shall not here or at this time enter further upon, but shall proceed to the investigation of the mechanica lpower given out or produced by such jets.

It will be necessary, as in the case of the furnace, to ascertain the amount of mechanical force exerted by jets of steam of given dimensions, and number in lbs. pressure per square foot of area of shaft, or horses' power, which we shall first of all do by ascertaining the evaporating power of a boiler, or a certain number of boilers, such as are used in the collieries where the steam jet has been applied.

The form of boiler ordinarily employed is cylindrical, with hemispherical ends, generally 30 feet long by 5 feet, to 5 feet 6 inches diameter; high pressure, of course. The evaporating power of such a boiler we may take at about 50 cubic feet of water per hour; and as the evaporation of one cubic foot of water per hour is generally taken to represent a horse's power, or 33,000 lbs. lifted one foot in height in a minute, we may take one of such boilers, used as a mechanical force, or as made to act as a jet of steam, as representing 50 horses' power, and so on for any greater number.

We shall now inquire what number of jets such a boiler will supply with steam, say at 40 lbs. per square inch.

Mr. Vivian quotes, in his evidence in 1849, "a Cornish boiler, 30½ feet long, 6 feet 2 inches diameter, as supplying a steam jet with an opening of ¾ inch square, the safety-valve lifting at 50 lbs. per square inch;" thus making one jet, of an area of ·5625 square inches, pass all the steam of such a boiler at 50 lbs. per square inch.

In an experiment which I made at Hetton Colliery with two boilers, each 26 feet long and 5 feet 4 inches diameter, the evaporation was 93 cubic feet of water per hour, into steam at 40 lbs. per square inch; and this quantity of steam was barely sufficient for the supply of 37 jets ½-inch diameter, or 1·8133 inches area. But this evaporation was more than would supply the same number of jets 3-16ths inch diameter, or 1·0216 inch area.

At Killingworth, I found the evaporation of three boilers, each 34 feet long and 5 feet 1 inch diameter, equal to 170 cubic feet of water into steam at 40 lbs. per square inch per hour; and this quantity of steam was also barely sufficient to fully keep up 29 jets 3-8ths of

of an inch diameter each, or 3·203 inches area, the boilers being, in this case, very vigorously fired.

At Tyne Main Colliery two experiments were made, the jets being placed at the top of the pit, a short distance from the boilers, and, consequently, little or no condensation. In one experiment there were 33 jets 3-16ths inch diameter each, and 28 jets 3-8ths inch diameter each, the total area being 4·0003 inches. There were two boilers, each 30 feet long, and 6 feet diameter, with hemispherical ends; the evaporation was 115 cubic feet of water per hour, and the pressure of steam 22·5 per square inch. The boilers were very hard fired, and the steam kept up with great difficulty. The other experiment was with the same boilers, steam at 40 lbs. per square inch; 61 jets 3-16ths inch diameter each; area of jets, 1·684 inches; and the evaporation was 109 cubic feet of water per hour, but the steam was blowing off strong all the time, the evaporation being more than the jets could pass.

The velocity with which elastic fluids rush into a vacuum is that which a heavy body will acquire by falling through a homogeneous column equal to the height due to the pressure or elasticity of the fluid; and the velocity with which a fluid of one degree of elasticity will rush into an atmosphere of a different degree of elasticity, is that which a heavy body will acquire by falling through a homogeneous column equal to the height due to the pressure, or difference of degrees of elasticities of the two fluids.

If we have, therefore, the degree of elasticity or density of steam, we shall know at what velocity such steam will rush into the atmosphere, through a jet or aperture, out of a pipe containing a continuous supply of steam at such a density. This theorem is well known, and is—

$$v = 8\sqrt{86{\cdot}5\ (459 + t')}$$

t' being the temperature of the steam above the pressure of the atmosphere. (*See* Tredgold on the Steam Engine, p. 89).

This expression of velocity is, however, correct only when the motion is free from friction, or unretarded. Mr. Tredgold states, "that the velocity through a tube, from two to three diameters in length, should be 6·5 instead of 8."

In the case of the steam jet, however, the jets are necessarily at some distance from the boilers, and the steam will be conveyed from thence by steam pipes of different diameters, and, consequently, we may assume that the velocity will be further diminished. The velocity of steam at 40 lbs. pressure per square inch, or 288·4° temperature, will be—

v $6{\cdot}5\sqrt{86{\cdot}5\ (459+288{\cdot}4)} = 1652{\cdot}7$ feet per second, the velocity with which the steam would issue from the jets.

The quantity of water evaporated at Hetton was 93 cubic feet per hour; we then have,

$$\frac{93\times506\times144}{3600\times1{\cdot}8133} = 1038 \text{ feet per second,}$$

the velocity with which 93 cubic feet of water converted into steam of 40 lbs. pressure per square inch, 506 bulk per minute, would pass through an aperture of 1·8133 inches in area. And at Killingworth $\frac{170\times506\times144}{3600\times3{\cdot}203} = 1074$ feet. And at Tyne Main, No. 1 experiment, $\frac{115\times959\times144}{3600\times4{\cdot}003} = 1102$ feet; and No. 2 experiment, $\frac{109\times504\times144}{3600\times1{\cdot}684} = 1311$ feet per second, the velocity of the steam out of the jets. The theoretical expression of these experiments being about 4·25 on the average (the last experiment not passing all the steam), instead of 6·5, as given by Tredgold; which is probably the more correct expression, as Tredgold gives 5· as the expression when the steam issues through a thin plate, and 5·45 through a tube of two or three diameters in length, projecting inwards.

Assuming 4·25 as the expression, we would have the velocity with steam at 40 lbs. = 1080·6 feet per second; and at 50 lbs. = 1088·4 feet per second.

Having thus the number of boilers, or area of surface of evaporation, and reckoning in round numbers, 3 square feet of surface of evaporation for each cubic foot of water evaporated, we shall know the mechanical power employed in any steam jet apparatus, and resolving the quantity of water into steam of the elasticity intended to be used, and adopting the theorem

$$v = 4{\cdot}25\ \sqrt{86{\cdot}5\ (459 + t'}$$

t' being the temperature of the steam equivalent to the elasticity intended to be used, we can also determine the number of jets to be used.

And if we wish to know the number of horses' power of the steam employed in the jets, or the pressure per square foot of area of shaft, we can also determine these.

Thus, suppose the pressure of steam employed in the jets to be 40 lbs. per square inch = 288°4 Fah. Then $4{\cdot}25\ \sqrt{86{\cdot}5\ (459 + 288{\cdot}4)} = 1080$ feet per second, the velocity with which the steam will issue from the jets.

Take the case of Tyne Main. 61 jets 3-16ths of an inch in diameter each = 1·6843 inch area: we have, as above, 1·6843 inches of steam, at 40 lbs. pressure, with a velocity of 1080·6 feet per second. Then $\frac{1080{\cdot}6\times1{\cdot}6843\times60}{144} = 758{\cdot}37$ cubic feet of steam per minute, and as the bulk of steam as compared with water is as 506 : 1, we have $\frac{758{\cdot}37}{506} = 1{\cdot}5$ cubic feet of water per minute, or 90 cubic feet per hour required to be evaporated to supply jets of the area of 1·6843 inches, with steam at 40 lbs. pressure per square inch.

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And if we require to know the pressure per square foot of area of shaft, in the same terms as Table III. of furnace ventilation, we have 758·37 cubic feet of steam, to act upon an area through the cylinders, of 40·25 feet, with steam at 40 lbs. per square inch pressure, now $\frac{758{\cdot}37}{40{\cdot}25} = 18{\cdot}84$ feet per minute, the quantity of steam supplied at 40 lbs. But the velocity of the air is 1231·6 feet per minute (viz., 49·574 cubic feet of air per minute passing up the shaft, the area of which is 40·25 feet), therefore, as 18·84 feet : 1231·6 feet : : 40 lbs. : ·6118 lbs. pressure per square inch, or ·6118 × 144 = 88·10 lbs. per square foot of area of shaft.

$$\text{And } \frac{88{\cdot}11 \times 40{\cdot}25 \times 1231{\cdot}6}{33{\cdot}00} = 132 \text{ horses' power.}$$

Resistance of the Air in Mines.

I shall now proceed to the consideration of the resistance of the air in mines, or to *C*, and, as previously noticed, this is a most important and a most difficult undertaking, requiring a much more elaborate and extensive investigation than I can pretend to bestow upon it on such an occasion as the present. I have found it necessary to enter upon it on a somewhat extensive scale, however, in order to obtain data whereby to compare the effective performances of the different systems of ventilating power; and I trust such researches, and the data which I have obtained from the experiments I have found it necessary to make in illustration thereof, will not be without their value, in the consideration of the ventilation of mines generally.

The mode by which mines are ventilated is by conveying the atmospheric air through all the passages, drifts, and openings which have been made in the excavation of the coal, so far as it is practicable to do so. In what is called the goaf, or goaves, viz., large spaces where the coal has been entirely taken away or excavated, and where the roof has been allowed to fall, or where the upheaving of the bottom of the mine has closed, entirely or partially, the space out of which the coal has been excavated, the atmospheric air cannot be made to traverse; and in those cases it is carried along the edges of those spaces, or along the edges of the goaves. But in all other parts of the mine the atmospheric air is made to traverse, to sweep away, mix with, or dilute the noxious gases which are evolved, either in the operation of working the coal, or in the old workings of the colliery, and so convey them to the surface harmlessly.

In collieries which have been a long period in working, and in some of the deep mines, where the expense of sinking is very great, the extent of the workings and of the air passages are very extensive, extending to many miles, through which it is necessary that the air should be made to traverse.

It has been generally understood that Mr. Spedding, of Whitehaven, was the first who attempted anything like a system of what is called "coursing the air," or carrying the air through the workings of a colliery, by a system of stoppings or brick walls, closing up some of the passages, and forcing the air along others, and so causing it to circulate through all the old or left-off workings. Previously to this being done, it would appear that the air was only made to circulate around those parts of the mine where the men were at work.

According to Mr. Spedding's system, the air was taken from the downcast shaft, and circulated in one unbroken current through the whole of the workings and waste. Mr. Buddle, finding this difficult to do in the extensive collieries of Northumberland and Durham, adopted the system of what is called "splitting the air," or, instead of carrying the air in one unbroken current from the downcast, around all the workings, to the upcast shaft, to split such current into subdivisions, and which also shortened the length which each current had to traverse.

The advantage of this is very obvious, the resistance of a current of air being directly as the length of the current, and the square of the velocity of the air, the current being shortened, the resistance in that respect is diminished, in the ratio of the diminution of the length of run; and the current being divided, the initial velocity is also reduced, and this diminishes the resistance in the ratio of the square of the velocity of the current, before and after being split. This has been carried to a great extent in some of the extensive collieries, even as many as 20 to 30 splits or separate currents existing in some of the mines.

It would have been extremely useful if, in an inquiry of this kind, we could have ascertained and laid down some practical rules by which the resistances of the air in one colliery could be correctly compared with that of another; we should then have been able, by comparing the practical effect of the jets in one colliery with the furnace in another, to have more readily determined their relative merits.

In the present state of our information this, however, cannot be done with any degree of accuracy. I have obtained the length of the air courses of several collieries, their area, the quantity of air traversing each split, and as much information as I could obtain, but the results are not such as I can present with confidence. There are so many elements requisite to determine with sufficient accuracy, in a practical point of view, the power required to produce a given velocity of current, or a determined amount of ventilation, that I find it would take more time than has been allowed me to make the requisite experiments and investigations to determine this most important question.

In

In comparing two collieries, one with furnace and the other with steam jet ventilation, we should have to take into consideration, in a conclusively practical manner, all the comparative effects as regards the length of the air courses, their area, and the superficies of the drifts, the velocity with which the air in each of these splits travel. We should also have to take into account the manner in which the splits are taken off from the main currents. Whether they are independent splits passing from one shaft to the other, without interference with any other current, or whether they are currents detached from the main current, made to travel certain workings, and again join the main current, and probably even some of those splits or detached currents are again subdivided, and either made to join the original main current, the detached current, or probably some other current.

I would simply direct the attention of the inquirer to the system of the Hetton Colliery ventilation, Appendix, No. I. There are in that colliery five main currents of air; these are subdivided into 35 splits, and, as will be seen by the statement, some of these splits proceed for a certain distance united, are then subdivided, and in some cases are mixed with other splits, and in all these peregrinations the area of the air courses vary every yard, and consequently the velocity of the current, which form so important an element in the resistance, varies likewise. After great labour and consideration, I have despaired in deducing, even from a variety of cases, anything like correct data whereby to compare dissimilar cases with each other. The conclusion I have therefore come to is, that the only correct mode of comparing the two systems of ventilation is to ascertain their comparative powers at the same colliery, and under as precisely the same circumstances as possible.

In the investigation, however, of this subject, it will be necessary to determine the predominant principles which govern the passage of the currents of air through coal mines, without which we cannot correctly ascertain the comparative merits even at the same colliery.

In the investigation of the resistance of the currents of air in a mine, we must take into consideration the lengths of the different currents; there will be in every mine what may be termed the main or ruling current, similar to what is termed the ruling gradient of a railway, viz., the current or currents which are the longest, and which present the greatest resistance, and by which the several minor currents are ruled or regulated.

In determining the resistance of the currents of a mine, it is not enough that we should take the number of splits, their respective lengths, their areas, and either obtain an aggregate length and mean area, or yet an average length and a mean area. These would not give accurate representations of the aggregate resistances. And as in the course of this investigation we shall have to advert to this, and to compare the amount of the resistance of the ventilation of one colliery with another, it is necessary that this should be thoroughly understood, though it may appear tedious and prolix.

I shall take a case which may be tabulated as follows, and which is shown on sketch in Fig. 12, Plate II., where *A* represents the downcast, *B* the upcast shaft, and Nos. 1, 2, 3, 4, and 5, the different currents of air.

TABLE showing the VENTILATION of a COLLIERY.

Number of Currents.	Quantity of Air, in Cubic Feet, per Minute.	Distance in Feet each Current of Air travels.
		Feet.
No. I. - - - - - - - -	38,000	- - - - 19,470
II. - - - - - - - -	4,400	- - - - 6,400
III. - - - - - - - -	13,020	1518 + 1650 + 7768 = 10,836
IV. - - - - - - - -	5,400	1518 + 1650 + 4470 = 7,638
V. - - - - - - - -	7,500	- - 1518 + 3300 = 4,818
VI. - - - - - - - -	14,000	- - - - 210
TOTAL - - -	82,320	Average distance - - 8,229

The ruling current here is No. 1, that of 38,000 cubic feet per minute, traversing a distance of 19,470 feet. Supposing the velocity of the air to be the same in all the currents, then, the resistance being as the length of the current, the natural tendency of the air would be to take the nearest route to the upcast, and so abstract a quantity of air from the longest route, or from No. 1; a regulator is therefore put into the air course, No. 2, at *A*; another into No. 3, at *B*; into No. 4, at *C*; and into No. 5, at *D*.

All those regulators contract the area of the passages, produce a corresponding increase of velocity in the current, and as the resistance is as the square of the velocity of the current, the area is so contracted until the resistance of the air through the regulator of the minor currents is equal to that of the long current, and then there is an uniform resistance produced, and each current then retains the quantity of air allotted to it.

Appendix, No. 1.

It will be seen, however, that each minor current of air, though the distance it travels is much less than that of the longest current, is made to have the same resistance, and that, therefore, the aggregate resistance will be represented by the total quantity of air multiplied into the length of run of the longest current, or by $83{,}000 \times 19{,}470$. This has an important bearing upon the ventilation of extensive coal mines, and on the subject under consideration.

Assuming this to be the correct view of the case, then the difficulty is considerably diminished in estimating the amount of resistance or drag of the air in any coal mine; as, having once obtained the amount of resistance, by experiment or otherwise, of any defined length of current and area of air passage, we have only to take the length of the longest current, its area and superficies, by which to ascertain the resistance of all the other currents, and so obtain the aggregate resistance, or C.

To determine the value of C, even with this limitation, is, however, attended with considerable difficulty: the variation in the dimensions of the air courses, passages, goaves, and route which the one main current has to take is so great, that it can only be determined by experiment; and when determined in one case, it is no rule for another, the main current of one pit differing in all these circumstances very much from another.

Mr. Hawksley, of Liverpool, has given a theorem, which is the result of a great many experiments on gas conveyed in pipes of many miles in extent, which is generally considered to be the most accurate that has been put forth, and which having been deduced from pipes of a uniform area, is likely to be much more accurate than any theorem deduced from the variable area and superficies of a current of air in a coal mine.

Let v = Velocity of air in feet per second.
T = Temperature of the upcast shaft.
D = Depth of shaft in feet.
t = Temperature of the downcast shaft.
s = Sectional area of the air courses in feet.
m = Corresponding margin, or superficial area of dimensions of air courses in feet.
l = Length traversed by air in feet.

$$v = 96\sqrt{\frac{\left(\frac{T-t}{T+448}\right) D\ s}{l\,m + 360\,s}}$$

I give this theorem, as I believe it has not hitherto been published, and because it has been found to be extremely correct in passages, or through pipes with smooth superficies; the co-efficient will require to be altered in its application to coal mines, but it may probably be of utility, in the further elucidation of the subject, when a general co-efficient deduced from numerous experiments has been obtained.

An attentive consideration of this part of the subject shows of what importance it is to attend to the most judicious and proper distribution of the air in a coal mine of even moderate extent. It is in vain to indulge in improved systems, or applications of powerful ventilating powers, if a proper distribution of the air is not carried out in the mine when it is obtained. It may be all thrown away by increased resistances arising from an improper system, or distribution of the air through the passages of the mine; and we shall see afterwards that the same ventilating power in different cases produces very different results.

This is obvious when we keep before us that the resistance of the air through a mine is directly as the length of the main or ruling current, and as the square of the velocity with which the air is made to travel, not through all the length of the air passages, but through even an inconsiderable distance. Mr. Gurney speaks of the "vena contracta" as a powerful obstacle in the ventilation of coal mines. Every regulator is a vena contracta; every obstruction or diminution in the area of the air passages below the proper dimensions is a vena contracta, all operating in a geometrical ratio to obstruct and diminish the quantity of air, and to increase the resistance to the ventilating power.

Let L = the length of the air courses, A = the area representing the velocity of the air, and P = the ventilating power, then $P = L \times A^2$. Thus, taking the case before us, the average length of the six currents is 8,229 feet, the entire length is 49·372 feet, L in the one case being 1, and in the other 6. Supposing the air is equally divided amongst six drifts in the one case, and a single continuous current in the other, the difference of ventilating power required will be $6 \times 1^2 = 6$; and $6 \times 6^2 = 216$, or 36 times the power in the one case as in the other; and taking the No. 1 current as the ruling one, and supposing the other minor currents to be obstructed by regulators, or area of drifts, so as to equalise the resistance, the difference will be as 36 : $\left(6 \times \frac{19470}{8229} \times \frac{82{\cdot}320}{38{\cdot}000} =\right)$ 66·62. or nearly double the power. Too much attention cannot, therefore, be paid to the proper distribution of the air, so as to have the shortest possible air currents and the largest area of air courses consistently with having the requisite quantity of air in each current, and with economy and the practicability of obtaining spacious air courses.

Water Gauge.

We have now practically to ascertain the value of *C*, and for this purpose I have made use of the water gauge. This is a very simple, but very effective instrument. It is in the form of a bent glass tube, open at both ends, shown in Fig. 1, Plate II., and the mode of application is thus:

A, has been made to represent the pressure or weight of column of the air in the downcast shaft of a mine, *B*, the weight of the column of air in the upcast shaft; and we have seen, or it is indeed apparent, that if there was a free communication between them along the drift or passage *C*, Fig. 1, Plate I., a current of air would, in furnace ventilation, be produced continuously, so long as the temperature of the column *B* was greater than that of *A*: and if any other system of ventilation is adopted, either to force the air down the shaft *A*, or to pump or force the air up the shaft *B*, or if a compound system is adopted, to force the air down the shaft *A*, and at the same time pump or force air up the shaft *B*, so long as these mechanical forces act, so long will a current of air be produced down the shaft *A*, along the passage *C*, and up the shaft *B*.

When we employ all or any of the mechanical powers to ventilate a coal mine, we close the passage *C*, and so cause the air to pass around the workings, as explained in Fig. IV, and which is generally done by placing a door at *A*, in the passage *C*. It is now quite clear that the difference of pressure between one side of this door and the other is a correct measure of the force or power required to propel the current of air around the workings of the mine; and a water gauge placed in this door, one end being open to the upcast and the other end open to the downcast, the difference of height of water in the two columns will exhibit a correct admeasurement of the pressure or force required to produce the different currents of air. It has been in this manner that the force, or the resistance of air at the different velocities, in these experiments was obtained. This will be more clearly shown by a reference to the diagram, Fig. 12, Plate II., where *a* represents the door (one being opened) on which the water gauge was applied.

The "water gauge," therefore, placed in these doors, indicates the force or pressure which is required to compel the air to traverse the workings, or, in other words, indicates the measure of force required to overcome the drag of the air around these workings or around the mine, and being a correct indicator of the power or force required to cause the current to traverse the workings of a coal mine (such as represented in the diagram), is the best instrument to measure, not only the actual amount of such force, but also the power required to produce currents of different velocities, and can also be made use of to ascertain the relative power of different ventilating forces.

The water gauge, however, it is necessary to remark, does not represent the entire amount of the ventilating power. It is an indication of the difference of pressure between one side of the door and the other, and indicates correctly the resistance and power required to keep in motion the different currents of air traversing the mine after passing one side of the doors until they return to the other, but it does not indicate or measure the force required to propel the air over the furnace and up the shaft.

In estimating, therefore, the relative amount of power employed in the different systems of ventilation, we must take these into consideration, and we shall see hereafter that this is important. In our investigations we shall therefore endeavour to ascertain the power required to propel the air around the workings, and also that which is required to propel it up the shaft, or, the resistance opposed to the ventilating power in propelling the air around the workings, and the resistance opposed by the furnace and column of heated air in the shaft, in furnace ventilation, in the one case, and by the column of heated air and steam in the shaft, in the case of steam jet ventilation, in the other.

The water gauge placed at the doors *a* in the passage, shown in the diagram, will not, as before stated, indicate the resistance in the upcast shaft, or the power required to force the air over the furnace, or through the jet apparatus; but, if we know the total amount of ventilating power employed (whatever that power may be), and if we can with the water gauge measure the amount of power required to force the air around the workings of the mine, or what may be called the effective ventilating power, we can then obtain the remaining resistance or loss of power by the different modes of ventilation, from whatever cause such loss may arise. The water gauge, therefore, we shall find to be a most useful instrument in ascertaining the practical or effective amount of ventilating power, or of the resistance to ventilation, and consequently of the value of *C*.

EXPERIMENTS made to Determine the actual as well as the relative Powers of the Furnace and Steam Jets as Ventilating Powers.

The collieries at which these experiments were made were the Hetton, Killingworth, and Tyne Main Collieries. They are what may be called deep collieries, being respectively 900, 690, and 672 feet in depth, and an experiment at the Norwood Colliery, 252 feet in depth.

Appendix, No. 1.

At Hetton Colliery the jets were placed at the bottom of the pit, the boilers, and consequently the fires, being also at the bottom of the pit; consequently the experiments at the Hetton Colliery embrace the ventilating power by—

1. Natural ventilation	At the bottom of the pit.
2. Engine fires alone	
3. Engine fires and steam	
4. Engine fires, steam, and jets	
5. Furnace	
6. Furnace, engine fires, and steam	
7. Furnace, engine fires, steam, and jets	

At Killingworth the jets were placed at the bottom, and likewise at the top of the pit, but the boilers being placed on the surface, the steam was taken down the shaft in pipes; and, therefore, an opportunity presented itself of ascertaining by experiment—

Natural ventilation	At the bottom of the pit.
Steam	
Steam and jets	
Furnace	
Furnace and jets	
Jets	At the top of the pit.
Furnace at bottom and jets	ditto.

These experiments would have been sufficient to test the comparative powers of furnace and steam jet ventilation, in almost all the varieties in which they can be applied, and likewise the actual amount of their ventilating powers in the several modes of application; but in the experiments on the power of the jets as a propulsive force alone, unaided by the rarefaction of the air in the shaft, I did not consider the experiments at Killingworth quite conclusive. It is only by placing the jets at the top of the pit that the propulsive force can correctly be ascertained. The Killingworth shaft is of an uniform area, and only 30·08 square feet. When the jets and cylinders were placed in the shaft, and all the openings, except through the cylinders, closed up, the area was reduced to 19·14 square feet, which I considered too small an area to test the actual powers, though the experiment was good, comparatively, the obstruction applying equally to the jet and the furnace, as the air from both passed through the cylinders.

The Tyne Main Pit is eight feet diameter, or 50·265 feet area, except about 34 yards, commencing 84 yards from the surface, where the tubbing is lined with fire-brick, and where the diameter is only 7½ feet, or 44·178 feet area. For about 70 feet at the top of the pit the diameter is however 9 feet, and this presented an opportunity of placing within this increased area a larger number of jets, and also to obtain a larger area for the air to pass through the cylinders, viz., 40·257 square feet, which may be considered a sufficient area to test the impulsive force of the jets placed at the top of the pits.

The experiment at Norwood Colliery was made to test the comparative merits of furnace and jet ventilation in pits of small depths, the jets being placed 180 feet from the surface, and the furnace 252 feet from the surface.

I shall now describe the mode in which the experiments were conducted.

Hetton Colliery Experiments.

The Hetton Colliery, or that part of it at which the experiments were made, comprises one upcast shaft, called the Blossom Pit, and two downcast shafts, the Minor and Eppleton shafts. The two former shafts are 900 feet in depth, and the latter 1,080 feet. A small portion of air passing up the upcast shaft proceeds from another downcast shaft, called the Elemore, but the great bulk of the air of that shaft passes up a separate upcast, which was not made the subject of experiment. The upcast, or Blossom shaft, is 153 feet in area, and the two downcasts are respectively 98 and 58 feet area = 156 feet.

The ventilating power of the Hetton Colliery is obtained from three furnaces, one 9 feet in width, and the other two 8 feet each.

Fig. 3, Plate I., is a section of the Hetton shaft, near the bottom of the pit, showing the furnaces. *A* being the shaft or pit, *B B* the two furnaces, over which the air from the Minor

Minor Pit and Elemore passes, and *C* the furnace over which the air from the Eppleton Pit passes,—*D D* being the two sloping drifts up which the heated air from the furnaces pass into the shaft. *B B*, Fig. 6, is an elevation of the two Minor Pit furnaces, and *C*, Fig. 7, that of the Eppleton Pit furnace.

E, Fig. 3, shows the two boilers, *a a*, placed at the bottom of the pit for working two underground engines, and which were used in supplying steam for the jets, the heated air and steam from the boilers passing up a staple *F* into the sloping drift *D*, and so into the shaft *A*. *G* showing the position in which the jets were placed in the shaft, the steam being conveyed along the pipes *e e*. The diameter of the steam pipes were six inches. Fig. 8 is a plan showing the distribution of the jets in the shaft at *G*. Three sets of jets were used, viz., $\frac{3}{16}$, $\frac{5}{8}$, and $\frac{3}{8}$th of an inch diameter each respectively, 37 jets being the number in each case.

The workings of the Hetton Colliery, ventilated by the aforesaid shafts, are very extensive, spreading over an extent, in the Hutton seam, of upwards of 2,000 acres; comprising coal partially worked or standing in pillars, and coal entirely worked away or goaf. Table I., Appendix, is a synopsis of the ventilation, showing the distances which the different currents of air traverse, either together or separate, and which also shows the extent of the ventilation, and the manner in which the air is split and distributed throughout the workings.

It must be observed that there are three seams or beds of coal in working at Hetton Colliery: the Hutton seam, 900 feet; the Low Main coal, 780 feet; and the Main coal, 660 feet from the surface. The furnaces are 900 feet from the surface, and in the Hutton seam, and though these furnaces embrace the ventilation of the entire workings in all the seams, the air from the low main and main coal seam do not pass over them, but pass into the upcast shaft at their respective depths from the surface; and, as will be seen by the synopsis of the ventilation, the quantity of air passing around the workings of the Low Main coal seam is 29·200 cubic feet per minute, and in the Main coal 29·950 cubic feet per minute.

Tables I., II., III., and IV., are the experiments made to ascertain the actual as well as the comparative performances of the furnace and steam jet in producing ventilation. Tables V., VI., and VII., are those made to ascertain the consumption of coal, and power expended in the two systems, and to ensure accuracy, were carried on for a period of 12 and 24 hours respectively. Table VIII. being a summary, or general result, of the three latter experiments.

In the prosecution of these experiments, every care was taken to ensure accuracy. The temperatures in the upcast shaft were generally taken by two thermometers, suspended in the shaft at the different depths at the same time; self-registering were used at first, but after having had several broken, I was obliged to abandon the use of them, and to use common thermometers with the bulbs wrapped with cotton, to prevent them cooling down in taking them out of the shaft, but keeping them a sufficient time in the shaft to register the temperature. The dampness of the shaft, and the unavoidable variation in the temperature, as the furnaces or engine fires were more or less urged, produced some discrepancies in this result; which, however, though it would have been more satisfactory in a scientific point of view if a strictly accurate result could have been obtained, will be found not to have affected the general result, and were as accurate as I believe they could be under the circumstances obtained. The quantity of air was measured with gunpowder within the downcast shaft; the difference of specific gravity between the gunpowder smoke and the air passing down the shaft will slightly affect the actual quantity, making the recorded quantities rather less than the actual; but the comparative result will not be affected thereby in any appreciable degree. However, it may be made the subject of calculation if requisite. Every care was taken to ascertain the amount of water gauge and the quantity of coal consumed, and also the quantity of water evaporated, and the elasticity of the steam employed in the steam jet experiments. The boilers have what is called "flash" flues, and consequently the great quantity of coals used in the evaporation of a cubic foot of water is rather high; this can, however, also be made the subject of calculation if required.

TABLE I.

SYNOPSIS of Experiments on Furnace and Steam Jet Ventilation at Hetton Colliery, 12 October and 3 November 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast at 10 Fathoms.	Upcast at 55 Fathoms.		
12 October:											
7·0 P.M. -	Three furnaces and engine fires on, the steam blowing into upcast at 45 lbs.; pit just done working - - - -	30·091	31·051	30·976	48°	50°	66°·75	120°·2	148°·7	1·4	198,261
9·0 „ - -	Three furnaces only; engine fires damped - - -	30·101	- -	- -	46	48	67	104·3	126·6	1·3	187,580
3 November:											
7·15 P.M. -	Three furnaces and engine fires, the furnaces rather low -	29·252	- -	- -	47	49	66·5	- -	- -	1·1	—
7·30 „ -	Three furnaces in good order -	- -	- -	- -	- -	- -	- -	155	150	1·4	208,443
	31 jets, ¼-inch diameter, set on at 7·52 P.M.; steam 35 lbs. per square inch - - -	- -	- -	- -	- -	- -	- -	153	168	—	—
	Jets taken off at 8·19 P.M., and set on again at 8·43 P.M.										
9·0 „ -	Jets and three furnaces - -	29·271	- -	- -	- -	- -	- -	169	180	1·5	212,907

TABLE II.

SYNOPSIS of Experiments upon Steam Jet and Furnace Ventilation at Hetton Colliery, 29th, 30th, and 31st October 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Bank.	Bottom of Downcast.	Bottom of Upcast.	Bank.	Bottom of Upcast.	In Return Air.	Upcast at 10 Fathoms.	Upcast at 55 Fathoms.		
29 October:											
6·0 P.M. - -	Three furnaces and engine fires	29·120	- -	- -	51°·5	- -	- -	170°	—	—	—
6·30 „ - -	Ditto - - and steam just blowing off into shaft; pit just done working - -	- -	- -	- -	- -	- -	- -	- -	180°	- -	205,615
7·30 „ - -	Ditto - - - - -	29·1	- -	- -	48·5	- -	- -	173	180	1·5	201,274
9·00 „ - -	Three furnaces, engine fires, and 37 steam jets, $\frac{3}{16}$ths diameter; steam 40 lbs. per square inch - - -	- -	- -	29·93	- -	50°·5	64°·5	171	180	1·55	205,636
30 October:	Furnaces put out, and engine fires damped at 10·40 P.M. on 29th October, and remained out until 6·30 A.M. on 30th October.										
6·30 A.M. -	Natural temperature - -	- -	- -	- -	- -	- -	- -	83	85	·4	130,890
	At 6·30, engine fires lighted.										
9·30 „ -	Steam blowing off into shaft -	29·03	- -	30·06	45	- -	64	92	98	·6	139,176
	At 10·30, 37 jets, $\frac{3}{16}$ths diameter, put on steam, at 50 lbs. per square inch.										
12·30 „ -	Engine fires and jets - -	- -	- -	30·06	- -	47°	64	99	105	- -	149,284
2·30 P.M. -	Ditto - - - - -	- -	- -	- -	- -	- -	- -	98	- -	- -	150,873
	At 2·50, furnaces lighted, jets on as well as furnaces.										
6·0 „ -	Ditto - - - - -	- -	- -	- -	- -	- -	- -	155	164	1·5	207,093
	At 7 o'clock P.M., furnaces put out and engine fires damped, and remained so until 6 o'clock A.M., 31st October.										
31 October:											
6·30 P.M. -	Natural temperature - -	28·9	- -	- -	52	- -	- -	79	85	·35	104,414
	Furnaces lighted at 6·40 A.M.										
9·0 „ - -	Furnaces alone on - - -	- -	- -	29·75	- -	- -	69	150	172	1·35	201,960

TABLE III.

SYNOPSIS of Experiments upon Steam Jet and Furnace Ventilation at Hetton Colliery, 13 November 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge, in Inches.	Quantity of Air in Cubic Feet per Minute.
		Bank.	Bottom of Downcast.	Bottom of Upcast.	Bank.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 65 Fathoms.		
12 November:											
6·0 P.M.	The furnaces put out, and engine fires damped, and remained so until 8·30 A.M., November 13th	29·527	—	—	—	—	—	—	—	—	—
13 November:											
8·30 A.M.	Natural temperature	29·395			39°				80°	0·50	123,463
10·30 „	Engine fires only, steam just blowing off; at 10·40, engine fires set away		30·25			47°			89	0·60	132,053
11·30 „	Engine fires, and steam blowing into shaft			29,325			67° 30	87°	81	0·60	139,847
	37 jets, ¼-inch diameter, set on at 11·56; steam, 40 lbs. per square inch; evaporation of water, 1·55 cubic feet per minute.										
12·30 P.M.	Engine fires and jets	29·30			41·25			88	94	0·8625	164,376
1·30 „	Ditto						68·5	97	97	0·855	163,614
	At 1·39, jets taken off.										
3·48 „	Jets still off, and engine fires damped	29·293	—	—	—	—	—	—	—	—	—
	Natural ventilation					47			75	0·55	127,145
	At 4·3, lighted the three furnaces.										
4·30 „	Three furnaces alone							163	178	1·75	211,193
5·30 „	Ditto						68	179	211	1·95	225,176
	At 5·40, boiler fires put away; furnaces on also.										
6·6 „	Three furnaces and engine fires							194	226	2·00	229,918
	At 6·10, the jets set on; evaporation, 1·55 cubic feet per minute of water.										
6·26 „	Three furnaces, engine fires, and jets	29·287						200		2·05	234,118

TABLE IV.

SYNOPSIS of the Experiments on Furnace and Steam Jets at Hetton Colliery, 11 December 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge, in Inches.	Quantity of Air in Cubic Feet per Minute.
		Bank.	Bottom of Downcast.	Bottom of Upcast.	Bank.	Bottom of Downcast.	In Return Air.	Upcast at 55 Fathoms.	Upcast at 65 Fathoms.		
11 December:	Furnaces put out, as well as engine fires, at 8 P.M., December 10, and remained out until 8 A.M., December 11.										
8·0 A.M.	Natural ventilation	29·189			54°			73°			117,908
	Engine fires put away, and water in boiler raised to 45 lbs. per square inch, and kept at that pressure.										
11·30 „	Steam just blowing off		29·85		53			81		0·4	121,464
12·30 P.M.	Boiler fires put away, and steam blowing into shaft, same as when jets were on; two boilers, each 26 feet long, 5 feet 4 inches diameter, circular ends			29·8	55		68°	82	85°	0·55	129,569
	Jets set on at 12·40; 37 jets, ¼-inch diameter; = in area 1·8133 inch				55			89	93	0·67	149,401
1·30 „	Steam, at 40 lbs. per square inch							87	90		140,923
	Cleaning fires from 1·40 to 3·20.										
3·30 „	Jets on; steam, 45 lbs.	29·107						90	94	0·70	147,707
4·16 „	One furnace lighted at 3·40; Eppleton furnace, only, 9 feet broad, and bars 6 feet; only 4 feet of fire grate		29·8		56			95	97	0·80	166,826
5·30 „	Jets set on in addition to furnace; steam, at 45 lbs.				55			124	128	1·17	194,075
5·35 „	The other two furnaces lighted; jets on	29·187			56			166	170	1·45	—

TABLE V.

SYNOPSIS of Experiments made at Hetton Colliery, with Three Furnaces, during Friday Night and Saturday, the 26th and 27th November 1852.

TIME.	Temperatures. Bank.	Temperatures. 55 Fathoms.	Minor Pit. Area, 98 Feet.	Eppleton Jane Pit. Area, 58 Feet.	From Isabella Pit, Northway, through Lyons Waste to Blossom Upcast.	Total Quantity of Air passing down the Downcast Shafts.	Water Gauge, in Inches.	Consumption of Coals, &c.
			Cubic Feet per Min.	*Cubic Ft. per Min.*	*Cubic Feet per Min.*	*Cubic Feet per Min.*		
At 8 o'clock, P. M.	48°	130°	141,120	65,936	8,743	215,799	1·25	In the 24 hours, the two furnaces, *B B*, consumed 15,960 lbs. of coals, and the furnace *C*, 11,200 lbs. of coals; altogether in the 24 hours, 27,160 lbs., which is equal to 18·86 lbs. per minute, and 11,066 cubic feet of air for each lb. of coal consumed.
9 „ -	48	140	135,692	67,719	10,200	213,611	1·20	
10 „ -	46	135	135,692	67,719	9,415	212,826	1·20	
11 „ -	48	128	135,692	65,936	8,743	210,371	1·20	
12 „ -	46	130	135,692	65,936	8,743	210,371	1·20	
1 o'clock, A. M.	45	138	130,666	65,936	9,415	206,017	1·20	
2 „ -	47	144	135,692	65,936	8,743	210,371	1·20	
3 „ -	46	125	135,692	67,719	10,200	213,611	1·20	
4 „ -	44	135	135,692	65,936	10,200	211,828	1·20	
5 „ -	45	135	135,692	65,936	8,743	210,371	1·20	
6 „ -	46	138	130,666	65,936	8,160	204,762	1·10	
7 „ -	42	137	135,692	65,936	9,415	211,043	1·05	
8 „ -	44	138	130,666	65,936	8,743	205,345	1·15	
9 „ -	45	130	133,132	62,640	8,743	204,515	1·20	
10 „ -	47	128	130,666	65,936	8,743	205,345	1·05	
11 „ -	49	129	130,666	64,246	8,743	203,655	1·15	
12 „ -	50	120	130,666	65,936	8,743	205,345	1·10	
1 o'clock, P. M.	54	128	130,666	65,936	8,743	205,345	1·10	
2 „ -	55	125	130,666	65,936	8,743	205,345	1·10	
3 „ -	55	125	130,666	65,936	9,415	206,017	1·20	
4 „ -	52	120	130,666	65,936	8,160	204,762	1·20	
5 „ -	48	120	135,692	67,719	8,743	212,154	1·15	
6 „ -	48	120	135,692	65,936	8,743	210,371	1·15	
7 „ -	51	124	130,666	65,936	8,743	205,345	1·05	
8 „ -	50	128	130,666	67,719	8,743	207,128	1·10	
Average - -	44°	130°	133,394	66,094	8,978	208,466	1·20	

TABLE VI.

SYNOPSIS of EXPERIMENT made at Hetton Colliery with the STEAM JETS, 37 in Number, Quarter of an Inch in Diameter, 3 January 1853.

TIME.	Temperatures. Bank.	Bottom of Downcast.	In Return Air.	10 Fathoms.	65 Fathoms.	Minor Pits. Area, 98 Feet.	Eppleton Lane Pit. Area, 58 Feet.	Elemore Portion of Air through Lyons Waste.	Total Quantity of Air passing down the Downcast Shaft.	Water Gauge.	Pressure of Steam.	Consumption of Coals.
						Cub. Ft. per Min.	*Cub. Ft. per Min.*	*Cubic Feet per Min.*	*Cubic Feet per Min.*	*Inch.*	*Lb. per S. In.*	
At 6 o'clock, A.M.	- -	- -	- -	- -	- -	- -	41,760	6,800	—	—	—	Two boilers, each 26 feet long, 5 feet 6 inches diameter, with hemispherical ends.
7 „ -	- -	- -	- -	75°	85°	88,200	50,112	6,800	145,112	·65	—	
8 „ -	- -	- -	- -	85	90	98,000	48,185	6,800	152,985	·80	35	
9 „ -	45°	47°	- -	85	90	100,800	56,946	7,650	165,396	·80	35	18,200 lbs. of coals consumed in 12 hours is 25·28 lbs. per minute, and consequently 6,400 cubic feet of air per minute for each lb. of coal consumed.
10 „ -	- -	- -	- -	90	90	99,380	56,946	7,650	163,976	·80	40	
11 „ -	45	- -	68	88	89	99,380	59,657	7,650	166,687	·80	40	
12 „ -	- -	- -	68	90	90	100,800	56,946	7,650	165,396	·80	40	
1 o'clock, P.M.	45	46	- -	90	90	100,800	59,657	7,650	168,107	·80	40	
2 „ -	- -	46	- -	86	89	99,380	54,470	7,650	161,500	·80	40	1498·25 cubic feet of water evaporated in 12 hours, is 117·35 cubic feet per hour, or 58·67 cubic feet for each boiler, the evaporating surface being 394 square feet.
3 „ -	44	- -	- -	86	88	98,000	56,946	7,650	162,596	·80	40	
4 „ -	- -	- -	70	86	90	99,380	54,470	7,650	161,500	·80	40	
5 „ -	45	- -	- -	86	90	98,000	54,470	7,650	160,120	·80	35	
„ -	- -	46	- -	86	90	98,000	54,470	6,800	159,270	·75	40	
7 „ -	- -	- -	- -	87	90	98,000	54,470	6,800	159,270	·75	40	
Average - -	45°	46°	68°	86°	90°	98,317	54,250	7,346	159,913	·80	40	

TABLE VII.

SYNOPSIS of EXPERIMENT made on Saturday 8th January 1853, at Hetton Colliery, with the FURNACE *C*, Nine Feet wide.

TIME.	Temperatures. At Bank.	Bottom of Downcast.	In Return Air.	10 Fathoms.	65 Fathoms.	Minor Pits. Area, 98 Feet.	Eppleton Lane Pit. Area, 58 Feet.	Portion of Air through Lyons Waste to Blossom Upcast.	Total Quantity of Air passing down the Downcast Shafts.	Water Gauge, in Inches.	Consumption of Coals.
						Cubic Feet. per Min.	*Cubic Feet. per Min.*	*Cubic Feet per Min.*	*Cubic Feet per Min.*		
At 6 o'clock, A.M.	40°	45°	69°	110°	115°	112,000	59,657	8,743	180,400	1·25	In 12 hours, the furnace consumed 7·280 lbs. of coals, which is equal to 10·11 lb. per minute; and 16,320 cubic feet of air per minute for each lb. of coal consumed.
7 „ -	42	45	69	102	110	110,250	62,640	8,743	181,633	1·10	
8 „ -	40	45	69	103	112	113,806	52,200	8,743	174,749	1·10	
9 „ -	40	45	69	111	116	112,000	50,112	10,200	172,312	1·15	
10 „ -	40	45	69	95	98	110,250	48,185	7,650	166,085	1·05	
11 „ -	43	45	69	96	99	110,250	48,185	7,650	166,085	1·10	Area of fire-grate of furnace, 9 × 4 = 36 square feet.
12 „ -	44	44	69	85	86	103,765	46,400	7,650	157,815	1·00	
1 o'clock, P.M.	50	45	69	85	90	103,765	46,400	7,650	157,815	1·00	
2 „ -	48	45	69	85	86*	103,765	44,743	7,650	156,158	1·00	
3 „ -	50	45	69	80	78	103,765	44,743	8,160	156,668	1·05	
4 „ -	45	45	69	95	90	103,765	44,743	8,743	157,251	1·00	
5 „ -	47	45	69	93	88	103,765	46,400	7,650	157,815	1·00	
6 „ -	47	45	69	85	80	103,765	46,400	6,800	156,965	1·00	
Average - -	44°	45°	69°	94°	98·5	107,300	49,296	8,154	164,750	1·00	

* After this period, at the 65 fathoms, water dropped upon the thermometer, which affected the register.

TABLE VIII.

RESULT of EXPERIMENTS at Hetton Colliery.—CONSUMPTION of COAL.

TIME.	Description of Experiment.	Temperatures.					Cubic Feet of Air per Minute passing down the Downcast Shaft.				Water Gauge, in Inches.	Consumption of Coals.	
		At Bank.	In Return Air.	Bottom of Down-cast.	Upcast. 10 Fath.	Upcast. 65 Fath.	Minor Pit.	Eppleton Jane Pit.	Portion from Elemore Pit.	TOTAL.		Lbs. per Minute.	Cubic Feet of Air for each Lb. of Coal.
1852:													
26 and 27 November	3 furnaces -	44°	68°	45°	- -	130°	133,394	66,094	8,978	208,466	1·20	18·86	11·066
1853:													
3 January -	37 jets, ¼ inch diameter each	45	68	46	86°	90	98,317	54,250	7,346	159,913	·80	25·28	6·400
8 January -	1 furnace, 9 feet -	44	69	45	94	98·5	107,300	49,296	8,154	164,750	1·00	10·11	16·320

EXPERIMENTS AT KILLINGWORTH COLLIERY.

KILLINGWORTH COLLIERY presented a different mode of testing the comparative powers of the steam jet and furnace than Hetton; the boilers being at the top of the pit, and the steam being conveyed down the pit in pipes, gave an opportunity of comparing the furnace with the jet, having nothing but the rarefaction of the steam in the shaft to effect the experiments. And in this case the same jets were removed from the bottom of the pit to the top, to test the relative effect at the top and bottom of the pit, and so that, in the former case, no force but the impulsive force of the jets were employed.

Figs. 2 and 3, Plate II., are elevations of the mode in which the furnace and jets were applied at Killingworth, *A A* being the shaft, *B* the furnace, and *D* the sloping drift into the shaft. The boilers are placed about 40 yards from the pit, and the steam is conveyed down the shaft, as shown on the sketch, in pipes 10 inches in diameter, to a receiver *C*, at the bottom of the pit; *e f* representing the level of the surface. Fig. 4, is a plan of the furnace and shaft, and Fig. 5, an elevation.

In the record of the experiments, it is stated that the experiments were tried sometimes with the furnace doors shut, and sometimes with them open. In Fig. 4, it will be seen that there is a horizontal passage, parallel with the sloping drift *D*, in which two doors at *a b* are placed; these are the doors alluded to; when the doors were shut all the air passed over the furnace, but when open part of this air passed along the horizontal drift into the shaft, diminishing the intensity of the furnace in the latter case, and increasing it in the former, though adding to the resistance of the air over the furnace.

The Killingworth Pit is 14 feet diameter, but it is divided, by air-tight timber brattices or partitions, into 4 compartments, two of them being used as downcast shafts, one as an engine shaft, and the other that in which the experiments were made. Fig. 6, shows the distribution of the jets, 29 in number, when placed at the bottom of the pit; the same jets as used at Hetton. The Killingworth shaft is 690 feet in depth.

The same care was taken in the prosecution of those experiments as with those at Hetton Colliery.

The distance which the air travels at Killingworth is very different from that at Hetton; the division of the shaft at Killingworth used in the experiments not being in use for ventilating the colliery at all. The ventilating shaft being entirely an upcast pit, 12 feet diameter, with two furnaces, a small portion only of the workings around the shaft was used for the experiments, and regulators were put in to counteract the effect of the short run. The total distance which the air travelled was only 1,213 yards, the distance which the several currents travelled being as follows:—in a single current 160 yards; in two currents 333 yards; in three currents 533 yards, and in four currents 187 yards. The dimensions of the regulators are given in the experiments.

TABLE IX.

SYNOPSIS of Experiments on Furnace and Steam Ventilation at Killingworth Colliery, 15 November 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 55 Fathoms.		
15 Nov.:											
8·0 P.M.	Natural ventilation	28·85	29·53	-	50°	55°	60°	-	-	0·15	8,888
	16 jets, 3-8ths diameter, set on at 8·14 P.M.; steam at 40 lbs. per square inch.										
8·28 „	Jets only	-	-	-	-	-	-	90°	-	-	15,605
8·52 „	Ditto	-	-	-	-	-	-	-	93°	-	16,570
	At 9 P.M. lighted furnace, 7 feet wide, bars 6 feet in length, about 4 feet of fire.										
9·9 „	Furnace only	28·858	-	-	-	-	-	-	-	-	18,903
9·16 „	Ditto	-	-	-	-	-	-	-	-	-	20,334
9·46 „	Ditto	-	-	-	-	-	-	92	-	1·00	24,625

In these experiments the area of the regulator was 3 ft. 10 $\frac{7}{8}$ in. × 5 ft. 6 in., and regulators also placed at the splits of air.

TABLE X.

SYNOPSIS of Experiments on Furnace and Steam Jet Ventilation at Killingworth Colliery, 19 November 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 55 Fathoms.		
19 Nov.:											
5·40 P.M.	Natural ventilation	29·325	30·08	30·03	45°	55°	-	-	73°	·15	—
5·55 „	The air all passing through a regulator, 5 feet 6 inches by 1 foot 2$\frac{3}{8}$ inches	-	-	-	-	-	-	95°	97	·55	8,494
6·10 „	Steam blowing off into shaft; regulator opened to 5 feet 6 inches by 2 feet	-	-	-	-	-	-	98	98	·66	16,134
	Set on jets at 6·25 P.M.										
7·23 „	Jets 29 in number, $\frac{3}{8}$ths inch diameter each, 660 feet from bank; steam at 40 lbs. per square inch; furnace doors open	-	-	-	-	-	-	99	96	·62	15,783
7·26 „	Ditto, with furnace doors shut	-	-	-	-	-	-	-	-	·67	14,984
7·44 „	Regulator opened 5 feet 6 inches by 4 feet, doors still shut	-	-	-	-	-	-	-	-	-	16,259
	Opened steam valve further, so as to allow as much steam to pass as the boiler, with hard firing, could supply; furnace doors shut	-	-	-	-	-	-	102	-	1·10	25,164
8·32 „	With furnace doors opened	29·332	-	-	-	-	-	-	99	1·05	24,164
	$\frac{3}{8}$th jets taken off at 8·50, and $\frac{1}{16}$th jets put on; steam applied at 9·20 P.M.										
9·57 „	With 29 jets, $\frac{1}{16}$ths diameter; furnace doors shut	-	-	-	-	-	-	-	99	0·80	23,168
	Ditto - ditto, with doors open	-	-	-	-	-	-	92	-	-	24,143
	Jets taken off and steam made to blow into shaft without force (5 inches diameter pipe); doors open	-	-	-	-	-	-	-	99	0·70	20,708
	Lighted furnace at 10·50 P.M.										
11·21 „	Furnace, 7 feet by 4 feet, with doors shut	-	-	-	-	-	61°	100	142	1·00	25,328
12 „	Ditto - ditto	-	-	-	-	-	-	133	-	-	26,774
12·4 „	Ditto, doors opened	-	-	-	48	-	-	-	150	0·85	25,704

TABLE XI.

SYNOPSIS of EXPERIMENTS on FURNACE and STEAM JET VENTILATION at Killingworth Colliery, 19 and 20 November 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 55 Fathoms.		
20 November:	Furnace on all night from 12·4 A.M., last experiment 19th November, to 8·35, 20th November	29·175	-	-	43°	-	-	-	141°	—	—
9·5 A.M.	Ditto	-	29·83	29·84	-	55°	-	-	-	·78	—
9·15 „	Ditto	-	-	-	-	-	-	125°	-	·85	—
9·30 „	Furnace on, blazer down, and doors shut	-	-	-	-	-	-	-	-	-	23,102
9·56 „	Ditto, blazer up	-	-	-	-	-	60°·5	-	145	·80	24,220
9·59 „	Ditto, blazer down	-	-	-	-	-	-	122	-	-	23,359
	Jets set on at 10·25 A.M.										
	29 jets $\frac{3}{16}$th inch diameter each, with furnace doors shut	-	-	-	-	-	-	-	152	1·30	—
	Ditto, with furnace doors open	-	-	-	-	-	-	-	-	1·10	—
10·35 „	Doors partially opened, so as to keep the intensity of fire about the same as when the furnace above was on with blazer up	-	-	-	-	-	-	-	-	1·15	29,752
10·58 „	Jets and furnace on	-	-	-	-	-	-	144	155	—	—
11·49 „	Ditto	-	-	-	-	-	-	-	154	-	31,070
12 6 „	Ditto	-	-	-	-	-	-	151	-	1·2	31,661
	Jets taken off at 12·15 A.M.										
12·25 „	Jets off and furnace on	-	-	-	-	-	-	-	150	·85	—
12·39 „	Furnace only; doors closed	29·215	-	-	43½	58	-	130	-	-	24,588

TABLE XII.

SYNOPSIS of EXPERIMENTS made on FURNACE and STEAM JET VENTILATION at Killingworth Colliery, 2 December 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 55 Fathoms.		
2 December:											
6·45 P.M.	Shaft cooled down, natural ventilation, with furnace doors shut	29·429	-	-	40°	52° 25′	60°	71°	72°	·26	13,527
7·5 „	Ditto, furnace doors open	-	-	-	-	-	-	71	-	25	14,904
	Steam set on to blow into shaft at 8 P.M.										
8·26 „	Steam only; furnace doors open	-	-	-	-	-	-	103	112	·60	32,055
8·31 „	Ditto, furnace door shut	-	-	-	-	53	-	105	112	·58	29,250
	Jets set on at 9·40 P.M.										
	29 Jets, $\frac{3}{8}$-inch diameter each, blowing through cylinders 6 feet long and 11 inches diameter	—	—	—	—	—	—	—	—	—	—
9·40 „	29 jets, $\frac{3}{8}$-inch diameter each	29·455	-	-	-	-	-	100	109	—	—
9·59 „	Jets, furnace doors open, steam at 38 lbs. to 40 lbs	-	-	-	-	-	-	103	104	·61	34,314
10·48 „	Jets in cylinders, doors open	-	-	-	-	-	-	104	106	·65	35,523
	Cylinders taken off jets at 11·50	-	-	-	-	-	-	108	109	—	—
12·7 A.M.	Jets without cylinders, doors at furnace open	29·528	-	-	-	-	-	100	108	-	35,347
	Lighted furnace at 1 A.M.										
1·7 „	Furnace only, furnace doors open	-	-	-	-	-	-	122	125	·6	—
1·38 „	Ditto - with furnace doors shut	-	-	-	-	-	-	160	163	1 1	36,732
2·29 „	Ditto - blazer down (doors partially opened)	-	-	-	-	-	-	154	162	-	38,360
2·32 „	Ditto - ditto - doors 1 foot open	-	-	-	-	-	-	-	-	-	38,677
2·35 „	Ditto - doors wide open	-	-	-	-	-	-	134	145	-	38,360
	Jets set on with furnace.										
	Jets and furnace	-	-	-	-	-	-	155	162	—	—
		-	-	-	-	-	-	-	-	-	44,150
3·23 „	Furnace doors open	-	-	-	-	-	-	195	205	—	—

TABLE XIII.

SYNOPSIS of Experiments on Furnace and Steam Jet Ventilation at Killingworth Colliery, 4 December 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.					Water Gauge in Inches.	Quantity of Air in Cubic Feet per Minute.
		Surface.	Bottom of Downcast.	Bottom of Upcast.	Surface.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 55 Fathoms.		
4 December:											
11·8 A.M.	Shaft cooled down	29·505			44°	54°			65°	·25	9,176
	Steam set on to blow into shaft at 11·20 A.M.										
11·50 „	Steam only; furnace doors shut						60°		88	·55	28,888
	Set on jets at 12 A.M.: 40 lbs. per square inch.										
	29 jets, ⅜-inch diameter each; 2·83 cubic feet of water evaporated per minute.										
12·18 „	Jets only; with furnace doors open								101	·70	32,500
	Jets taken off, and furnace lighted 12·40 P.M.										
12·54 „	Furnace only; with blazer up and doors shut								135	·87	36,392
1·21 „	Ditto, and doors open								137	·95	37,741
1·51 „	Jets and furnace; doors open								164	1·25	44,570

TABLE XIV.

SYNOPSIS of Experiments on the Furnace and Steam Jet at Killingworth Colliery, 10 December 1852.

TIME.	DESCRIPTION OF EXPERIMENT.	BAROMETER.			TEMPERATURE.				Water Gauge.	Quantity of Air in Cubic Feet per Minute.
		Bank.	Bottom of Downcast.	Bottom of Upcast.	Bank.	Bottom of Downcast.	In Return Air.	Upcast Shaft at 55 Fathoms.		
10 December:										
4·30 P.M.	Natural ventilation; furnace doors opened				49°·25	53°·75	62°·25		·10	11,249
	Jets set on at bank at 5·40 P.M.; 29 jets ⅜th inch diameter each; steam at 40 lb. per square inch. Evaporation of water 2·83 cubic foot per minute.									
6·30 „	Jets only; furnace doors open						60	77°	·35	23,018
6·47 „	Ditto; furnace doors shut							78		21,467
	Furnace lighted at 7·40 P.M., and jets shut off.									
8·1 „	Furnace only; furnace doors shut							138		33,281
8·15 „	Ditto - ditto							132	·90	33,428
8·25 „	Ditto - ditto									32,880
	Jets set on, in addition to furnace, at 8·30 P.M.									
9·21 „	Jets and furnace; furnace doors shut	29·06						161	1·025	37,707
9·30 „	Ditto - ditto							152	—	—

Tyne Main Colliery Experiments.

Appendix, No. 1.

The experiments at Tyne Main were made with the furnace, and with the steam jets at the top of the pit. I have previously stated the reasons why these experiments were made, viz., that the increased area of the shaft, near the top, admitted of the jets being placed within the pit, the area within the cylinders (when the interstices were closed up) being nearly equal to the area of the shaft generally.

Fig. 7, Plate II, shows the mode in which the furnaces were applied at this colliery; *A* being the shaft, *B B* the furnaces, and *D* the sloping drift to the shaft. Fig. 9 is an elevation of the two furnaces, and Fig. 10 a plan of the same. Fig. 8 shows the jets placed at the top of the pit, *e f* being the level of the surface. The boilers in this case being about 30 yards from the top of the pit, and the steam conveyed from thence to the jets with a pipe 6 inches in diameter. Fig. 11 shows the disposition of the jets within the area of the shaft, 61 in number, the same jets as were applied at Hetton and Killingworth, $\frac{3}{16}$ths and $\frac{3}{8}$ths of an inch in diameter.

The workings of this colliery are not very extensive. There has been about 50 acres of coal entirely taken away, the space forming the goaf of the colliery. 158 acres of coal has been partially worked, about one-third excavated, and two-thirds remaining in pillars. There is, therefore, a space of 56 acres of excavation, and 50 acres of goaf to ventilate, $5\frac{1}{2}$ feet in height.

The total length of air courses is as follows:

No. 1 Split, 40,000 Cubic Feet per Minute.			No. 2 Split, 66,000 Cubic Feet per Minute.		
Number of Currents.	Distance Travelled in Feet.	Quantity of Air in Cubic Feet per Minute.	Number of Currents.	Distance Travelled in Feet.	Quantity of Air in Cubic Feet per Minute.
1, 2, 3	396	40,000	4, 5, 6	792	66,000
3	1,782	15,000	6	5,950	26,000
1, 2	7,392	25,000	4, 5	1,716	40,000
1	1,716	12,500	4	2,442	20,000
2	3,498	12,500	5	1,980	20,000
1, 2,	2,112	25,000	4, 5, 6	792	66,000
1, 2, 3	396	40,000			

The following Tables are the Experiments made:

TABLE XV.

SYNOPSIS of Experiments on the Furnace and Steam Jet at Tyne Main Colliery, 14 January 1853, there being Two Boilers, each 30 feet long, and 6 feet diameter, with 61 Jets, 28 of which were $\frac{3}{8}$th inch diameter, and 33 $\frac{3}{16}$th inch diameter; Cylinders 6 feet long, 11 inches diameter.

TIME.	DESCRIPTION OF EXPERIMENT.	TEMPERATURE. Bank.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 65 fathoms.	Pressure of Steam, lb. per Square Inch.	Water Gauge. East Door.	West Door.	Quantity of Air, Cubic Feet per Minute.	REMARKS.
								Inch.	Inch.		
11·23 A.M.	Natural ventilation - Jets set on at 11·40, with cylinders 6 feet long, 11 inches diameter	36°	42°	63°	62°	61°	- -	·2	·2	34,955	Furnace put out 10 P.M., January 13th, and remained out until 1·20 P.M. January 14th.
12·30 „	Jets alone	- -	- -	- -	- -	- -	35	—	—	—	
1·15 P.M.	Ditto	- -	42	- -	62	60	22·5	·3	·325	47,407	
	Jets taken off; furnace lighted at 1·20 P.M.	- -	- -	- -	62	60	22·5	- -	- -	46,834	Jets on 1 H. 40 M., consumed 3,548 lbs. of coal to evaporate 192·5 cubic feet of water, is 1·92 cubic feet of water, and 35·84 lbs. of coal per minute.
1·30 „	Furnace only	38	- -	63	102	105	- -	·775	·9	84,280	
2· „	Ditto	- -	- -	- -	144	138	- -	·875	1·	87,919	
2·30 „	Ditto	- -	42	- -	158	155	- -	·9	1·	101,137	
3· „	Ditto	- -	- -	63	160	144	- -	·9	1·	102,500	
					Upcast 35 Fas.	Upcast 75 Fas.					
3·30 „	Ditto - Jet set on with furnace at 3·30 P.M.	- -	42	- -	195	193	- -	- -	- -	99,805	
4 „	Jets and furnace	40	- -	63	198	260	30	1·2	1·3	108,300	Jets on 30 M., evaporated 119 cubic feet of water = 3·96 cubic feet per minute, water being low in the boilers, and no feed.

* Water falling on the thermometers.

TABLE XVI.

SYNOPSIS of Experiments on the Furnace and Steam Jet at Tyne Main Colliery, 15th January 1853, there being two Boilers, each 30 feet long and 6 feet in diameter, with 61 Jets, each $\frac{3}{16}$th of an inch in diameter; Area, 1·6843 inches; within Cylinders, 6 feet long and 11 inches diameter; Area = 40·258 feet.

TIME.	DESCRIPTION OF EXPERIMENTS.	TEMPERATURE.					Pressure of Steam, Lb. per Square Inch.	Water Gauge.		Quantity of Air, Cubic Feet per Minute.	REMARKS.
		Bank.	Bottom of Downcast.	In Return Air.	Upcast 10 Fathoms.	Upcast 65 Fathoms.		East Door.	West Door.		
								Inch.	Inch.		
	Jets set on at 8·45 A.M.	- -	- -	- -	- -	- -	-	- -	- -	- -	Furnace put out at 8 P.M., January 14th, and remained out until 12·40 A. M., January 15th.
10·20 A. M. -	Jets alone - -	- -	43°	- -	- -	- -	40	·3	·4	49,254	Jets on 2 H. 55 M.; coals consumed, 3,548 lbs., = 20·48 lbs. per minute; water evaporated, 318·5 cubic feet, = 1·82 cubic feet per minute, is 11·2 lbs. for each cubic foot of water evaporated, and 2,420 cubic feet of air for each lb. of coal consumed.
11· „ -	Ditto - - -	- -	- -	63°	64°	63°	40	·3	·4	49,574	
11·30 „ -	Ditto - - -	45°	- -	- -	63	61	40	·3	·375	49,574	
	Jets taken off at 11·40 A. M.										
12· „ -	Natural ventilation -	- -	- -	63	64	62	- -	·2	·2	36,564	
12·30 P. M. -	Ditto - - -	- -	43	- -	65	62	- -	·2	·2	37,182	
	Furnace lighted at 12·40 P. M.										
1· „ -	Furnace alone - -	45	- -	- -	188	180	- -	·8	·9	94,815	
1·30 „ -	Ditto - - -	- -	- -	63	189	223	- -	1·05	1·15	94,815	
2· „ -	Ditto - - -	- -	- -	- -	207	262	- -	1·05	1·18	99,805	
2·30 „ -	Ditto - - -	- -	- -	- -	- -	- -	- -	1·1	1·2	102,503	
	Jets set on with furnace at 2·40 P. M.										
3· „ -	Furnace and jets -	45	- -	63	210	272	40	1·15	1·25	105,350	Jets on 1 H.; coals consumed, 1,792 lbs.; water evaporated, 133 cubic feet, or 2·21 per minute.
3·30 „ -	Ditto - - -	- -	43	- -	- -	- -	40	1·15	1·25	106,830	

TABLE XVII.

SYNOPSIS of Experiment on the Furnace at Tyne Main Colliery, 20th January 1853.

TIME.	TEMPERATURE.					Water Gauge.		Quantity of Air in Cubic Feet per Minute.	REMARKS.
	Bank.	Bottom of Downcast.	In Return Air.	Upcast 10 fathoms.	Upcast 65 fathoms.	East Door.	West Door.		
						Inch.	Inch.		
6 o'clock, A.M. -	49°	- -	- -	105°	95°	6	·65	68,956	
7 „ - -	- -	52°	- -	130	100	·75	·80	88,200	The quantity of coals consumed by the two furnaces in 12 hours was 12,070 lbs, which is equal to 16·76 lbs. per minute, and 6,080 cubic feet per minute for each pound of coal consumed.
8 „ - -	- -	- -	63°	175	- -	·95	1·	99,805	
9 „ - -	50	- -	- -	163	- -	·95	1·	99,805	
10 „ - -	- -	52	- -	176	- -	·95	1·	99,805	
11 „ - -	- -	- -	63	170	- -	·90	·95	99,805	
12 „ - -	50	- -	- -	174	- -	·90	·90	102,500	
1 o'clock, P.M. -	- -	50	- -	161	- -	·90	·90	103,907	
2 „ - -	- -	- -	63	162	- -	·90	·90	105,350	
3 „ - -	49·5	- -	- -	149	- -	·90	·90	103,907	
3·30 „ - -	- -	- -	- -	- -	159	—	—	—	
4 „ - -	- -	50	- -	165	- -	·95	·95	109,933	
4·30 „ - -	- -	- -	- -	- -	160	—	—	—	
5 „ - -	- -	- -	63	159	- -	·90	·90	101,113	
5·30 „ - -	- -	- -	- -	- -	151	—	—	—	
6 „ - -	49·5	- -	- -	157	- -	·90	·90	108,360	
Average - -	49°·75	51°	63°	161°·75	145°·5	·904	·925	101,876	

TABLE XVIII.

SYNOPSIS of EXPERIMENT at Tyne Main Colliery on the STEAM JETS, 61 in number, $\frac{3}{16}$ths diameter each without the Cylinders, 28th January 1853.

TIME.	DESCRIPTION OF EXPERIMENT.	TEMPERATURE.				Quantity of Air, Cubic Feet per Minute.	Water Gauge.		Pressure of Steam, Lb. per Square Inch.	CONSUMPTION OF COALS, &c.
		Bank.	Bottom of Downcast.	In Return Air.	Upcast 30 Fathoms.		East Door.	West Door.		
10·30 A. M.	Natural ventilation	32°	- -	62°·5	65°	39,506	·3	·3	—	Furnace put out at 4 P. M., January 27th, and remained out until the experiments were finished.
11 „	Ditto - ditto	- -	40°	62·5	65	34,506	·3	·3	—	2,558 lbs. of coals consumed in two hours, and 248·5 cubic feet of water evaporated, which, in two hours, is 2·07 cubic feet per minute = 10·2 lbs. of coal to a cubic foot of water, and 2,223 cubic feet of air for each pound of coal consumed.
	Jets set on at 11·15 A. M.	—	—	—	—	—	—	—	—	
11·30 „	Jets alone	35	- -	62·5	68	47,407	·38	·38	40	
12 „	Ditto	- -	40	- -	63	47,407	·38	·38	40	
12·30 P. M.	Ditto	36	- -	62·5	62	47,407	·38	·38	40	
1 „	Ditto	- -	40	62·5	62	47,407	·38	·38	40	
	Average	35°·5	40	62°·5	63°.75	47,407	·38	·38	40	

NORWOOD COLLIERY EXPERIMENTS.

THE experiments at Norwood Colliery were made by Mr. Greenwell, for the purpose of testing the comparative powers of the furnace and steam jet, the area of the furnace bars being precisely the same as the area of the fire bars of the boiler; and likewise, for the purpose of testing their comparative merits in shafts of small depths.

Figs. 1 and 2, Plate III. show the manner in which the jets were applied, *A A* being the shaft. The shaft was divided by an air-tight timber partition or brattice, shown at *c d*, Fig. 1, and *d d*, Fig. 2, the air passing down the side *A*, and returning up the opposite side. *a a a*, Fig. 1, shows the steam pipe leading from the boiler to the jets, which were placed at *b*, 180 feet from the top of the pit; and *e e e*, Fig. 2, shows the distribution of the jets in the shaft. The furnace is shown at *g*, Fig. 1, at the bottom of the pit, and 252 feet from the surface, *B*, Fig. 3, being an elevation.

The shaft is 11 feet diameter, the area of the downcast being 73,766 feet, and the upcast 18,323 feet; the brattice occupying the remainder of the area. The steam pipe *a a a* was 3 inches diameter, the boiler with which it was connected being 28 feet long, and 6½ feet diameter; the number of jets were 26, $\frac{3}{16}$ths of an inch diameter each. The steam was kept at 33·8lbs. per square inch during the experiments. The area of fire grates of furnace and engine fire was 5 feet by 4 feet each.

The following Table will show the result of the experiments:—

TABLE XIX.

SYNOPSIS of Experiments on Furnace and Steam Jet Ventilation at Norwood Colliery, August 1852.

TIME.	DESCRIPTION OF EXPERIMENTS.	Barometer at Bank.	TEMPERATURE.				Coals consumed in 24 Hours.	Water Gauge in Inches.	Cubic Feet of Air per minute.	Water evaporated in 24 Hours.
			Bank.	Bottom of Downcast.	From Surface of Upcast. 21 Fathoms.	From Surface of Upcast. 15 Fathoms.				
							Lbs.			
August 10 -	Jets alone, bord end doors open - -	- -	- -	- -	- -	- -	6955·2	—	9,690	—
„ 12 -	Jets alone, bord end doors closed - -	29 16	59°	64°	- -	98°	6955·2	·26	6,000	—
	Steam alone, ditto -	- -	- -	- -	- -	- -	- -	—	2,880	—
	Furnace alone, ditto -	- -	- -	- -	- -	- -	- -	—	7,200	—
	Jets alone, bord end doors open - -	- -	- -	64	- -	98	7324·8	·20	8,000	—
	Furnace alone, ditto -	- -	- -	64	94°	- -	- -	·30	8,472	—
	Furnace and jets, ditto	- -	- -	- -	- -	- -	- -	·40	9,000	—
„ 13 -	Furnace alone, bord end doors closed -	- -	- -	64	100	- -	967·68	·30	8,000	—
	Furnace alone, bord end doors open -	- -	- -	64	100	- -		·40	9,600	—
	Furnace and jets, bord end doors open -	- -	- -	64	- -	112	- -	·50	11,064	—

We shall now investigate the practical results of the foregoing experiments. In the first place, however, it will be necessary to determine the resistances opposed to the moving powers of the furnace and steam jet, in order to compare their efficient performances in producing ventilation.

I have previously stated, that I employed the water gauge to measure the power required to force the current of air around the workings of the mine, and I have described the mode in which this was taken. In the prosecution of these experiments, the amount of water gauge exhibited, when the current was moved at different rates of velocity, was accurately taken; and the foregoing Tables will show the water gauge in a great variety of cases, and at very various velocities of current.

The following Tables are the result of these Experiments:—

TABLE XX.

EXPERIMENTS made to determine the Power required to produce different Velocities of Currents of Air in Coal Mines, ascertained by the Height of Water Gauge.

Hetton Colliery.

DESCRIPTION of POWER.	Date of Experiments.	Time of Experiments.	Water Gauge, Inches.	Quantity of Air in Cubic Feet per Minute.	Observations.
	1852:				
Three boiler fires and three furnaces - - -	12 October -	7· 0 P.M.	1·4	198,261	
Three furnaces - - -	12 „ -	9· 0 „	1·3	187,000	
Three boiler fires and three furnaces - - -	29 „ -	7·50 „	1·5	201,274	
Three furnaces - - -	29 „ -	8·15 „	1·55	205,636	
Natural ventilation - -	30 „ -	6·30 A.M.	·6	130,890	
Two boiler fires - -	30 „ -	9· 0 „	·6	139,176	
Two boiler fires, jets and three furnaces - -	30 „ -	6· 0 „	1·5	207,093	
Natural ventilation - -	31 „ -	6·15 „	·35	99,414	
Furnaces - - - - -	31 „ -	9· 0 „	1·35	201,960	
Three boiler fires and three furnaces - - -	3 November -	7·15 P.M.	1·4	208,443	
Three boiler fires and three furnaces - - -	3 „ -	9· 0 „	1·5	212,907	

(continued)

DESCRIPTION of POWER.	Date of Experiments.	Time of Experiments.	Water Gauge, Inches.	Quantity of Air in Cubic Feet per Minute.	Observations.
	1852:				
Natural ventilation	13 November	8·30 A.M.	·5	123,463	
Two boiler fires	13 „	10·30 „	·6	132,053	
Ditto and steam	13 „	11·30 „	·6	139,847	
Two boilers fires and jets	13 „	12·30 „	·8625	164,376	
Ditto	13 „	1·30 P.M.	·855	163,614	
Natural ventilation	13 „	3·30 „	·55	127,145	
Three furnaces	13 „	4·30 „	1·75	211,193	
Ditto	13 „	5·30 „	1·95	225,176	
Three furnaces and two boiler fires	13 „	6· 0 „	2·0	229,918	
Three furnaces and two boiler fires and jets	13 „	6·26 „	2·05	234,118	
Natural ventilation	11 December	8· 0 A.M.		117,908	
Two boiler fires	11 „	11· 0 „	·4	121,464	
Two boiler fires and steam	11 „	12· 0 „	·55	129,369	
Two ditto and jets	11 „	3·30 „	·7	146,010	
One furnace	11 „	4·16 „	·8	166,826	
Two boiler fires, jets and one furnace	11 „	5·55 „	1·17	194,075	

TABLE XXI.

Experiments on Water Gauge—*continued.*

Killingworth Colliery.

DESCRIPTION of POWER.	Date of Experiments.	Time of Experiments.	Water Gauge, in Inches.	Quantity of Air in Cubic Feet per Minute.	Observations.
Natural ventilation	15 November	8· 0 P.M.	·15	8,888	Regulators, 3 ft. 11 in. × 5 ft 6 in.
Furnace	15 „	9· 0 „	1·	24,625	
Natural ventilation	19 „	5·40 A.M.	·15	8,494	Regulator, 5 ft. 6 in. × 2 ft.
Steam only	19 „	6·14 „	·66	16,134	Doors opened.
Jets, $\frac{3}{8}$ths	19 „	7·17 „	·62	15,778	
Ditto	19 „	7·30 „	·67	14,984	Doors shut.
Ditto	19 „	7·40 „		16,259	Doors shut; regulator opened to 5 ft. 6 in. × 4 ft.
Ditto	19 „	8·10 „	1·10	24,164	Steam valve opened; doors still shut.
Jets taken off	19 „	8·30 „	1·05	24,164	Furnace doors open.
Jets, $\frac{3}{16}$ lb.	19 „	9·50 „	·80	14,917	- ditto - - shut.
Ditto	19 „	10· 2 „		15,390	- ditto - - open.
Steam only	19 „	10·17 „	·70	13,706	- ditto - - open.
Furnace	19 „	11·21 „	1·	25,328	- ditto - - shut.
Ditto	19 „	12· 0 „		26,775	- ditto - - shut.
Ditto	19 „	12· 5 „	·85	25,794	Doors opened.
Ditto	20 „	9·46 A.M.	·80	24,220	Regulator, 5 ft. 6 in. × 4 ft.
Furnace and jets	20 „	11·49 „	1·15	31,070	- ditto.
Furnace	20 „	12·39 „	·85	24,588	- ditto.
Natural ventilation	2 December	6·40 A.M.	·26	13,526	- ditto.
Steam only	2 „	8·26 „	·60	32,055	- ditto.
Jets, cylinders on	2 „	9·59 „	·65	35,454	- ditto.
Ditto off	2 „	12· 3 P.M.		35,454	- ditto.
Furnace	2 „	1·35 „	1·1	36,731	- ditto.
Ditto	2 „	2·26 „		38,677	- ditto.
Furnace and Jets	2 „	3·23 „	·96	44,150	- ditto.
Natural ventilation	4 „	10·45 „	·25	9,176	
Steam	4 „	11·50 „	·55	28,888	
Jets	4 „	12·15 „	·70	32,500	- ditto.
Furnace	4 „	12·50 „	·87	36,392	
Ditto	4 „	1·20 A.M.	·95	37,741	
Furnace and jets	4 „	1·50 „	1·25	44,570	

TABLE XXII.

EXPERIMENTS on WATER GAUGE—*continued.*

TYNE MAIN COLLIERY.

DESCRIPTION of POWER.	Date of Experiments.	Time of Experiments.	Water Gauge, in Inches.	Quantity of Air in Cubic Feet per Minute.	OBSERVATIONS.
	1853:				
Natural ventilation - -	14 January -	11·23 A.M.	·2	34,955	
Jets - - - -	14 „ -	1·15 P.M.	·325	47,407	
Two furnaces - - -	14 „ -	3· 0 „	1·	102,500	
Two furnaces and jets -	14 „ -	4· 0 „	1·3	108,300	
Jets - - - -	15 „ -	11·30 A.M.	·4	49,574	
Natural ventilation - -	15 „ -	12·30 P.M.	·2	36,873	
Two furnaces - - -	15 „ -	2·30 „	1·2	102,503	
Two furnaces and jets -	15 „ -	3·30 „	1·25	106,830	

I shall take the experiments in Table XIX., made on the 13th November 1852, as an example at Hetton Colliery; and in order to more clearly show the quantities of air produced with the different heights of water gauge, I have made a diagram, showing the curve of such increase, corresponding with the different heights of water gauge, which is shown in Plate IV. I have taken the experiments at Killingworth on the 4th December as an illustration of the effect of the water gauge at that colliery, the length of the current being very small compared with that of Hetton, and where the velocity of the air was obstructed, by having to pass through a regulator 22 feet area. The diagram, exhibiting the curve of the different heights of water gauge, is shown in Plate V; and I have taken the experiment of 15 January 1853 as the result of the water gauge in Tyne Main Colliery for the same object, Plate VI. showing the curve.

On an examination of these diagrams, it will be seen that the quantities of air produced does not materially vary from the square roots of the height of water gauge, or power employed to produce those quantities; the dotted lines showing the line according to the square roots, and the black line the curve of the quantities actually produced.

The power required to force the air around the workings is not, however, the only motive power required in the ventilation of a coal mine. The water gauge in these experiments is the power which is required to force the current from the one side of the doors *a*, Fig. 12, Plate II., from the downcast shaft *A*, around the workings to the other side of the doors in its return to the Furnace *F*. We have, in addition to this, the power required to force the current over the furnace *F*, and up the upcast shaft *B*.

This would appear of little moment, looking at the distance which the air has to travel from the side of the doors at *a*, Fig. 12, to the shaft *B*, and so to the surface, compared with the extent of air courses, as shown on the sketch in the Plate. But we shall see that this distance absorbs a considerable portion of the ventilating power, and presents an important element in the theory and practice of mine ventilation.

The air has first of all to pass over the furnace; and in order to produce the requisite vigour or intensity of combustion, and to consume the fuel as completely as practicable, the air is thrown upon the fire with great force, the passage over the furnace being contracted for that purpose; this presents considerable resistance to the free motion of the current. The air is now heated and expanded in bulk, its velocity is correspondingly increased, and as has already been demonstrated, the resistance being as the square of the velocity, the increased velocity presents increased resistance. It may be, that in practice the shaft may be made of a correspondingly increased area, so that the additional resistance due to the increased velocity of the current by its expansion is counteracted; but our intention being to ascertain the relative resistances at different rates of velocities induced by the increased temperature of the air, the experiments have of course been made in shafts of the same areas.

In order to show the curve resulting from the resistances over the furnace and up the shaft at the different velocities, I have made diagrams similar to those exhibiting the power required to force the air around the workings, which diagrams are shown in Plates VII., VIII., and IX.

The first column in these diagrams shows the temperature of the air passing down the downcast shaft; the weight of which per square foot of area of shaft will be seen in Table III.; the second column is the mean temperature of the air passing up the upcast shaft, the weight or pressure of which per square foot area can be similarly ascertained; the third column is the velocity of the air in passing down the downcast; the fourth column showing

Appendix, No. 1.

the increased velocity in the upcast by the increased temperatures; the fifth column is the quantity of air passing round the mine in cubic feet per minute, measured by powder smoke in the downcast shaft; the sixth column is the amount of water gauge, or power required, in lbs. per square foot of area of shaft, to force the air around the workings; and the seventh column shows the power required to force the air over the furnace and up the upcast shaft; being obtained by deducting the amount of water gauge in the sixth column from the difference between the weight of the column of air in the downcast and upcast shafts; thus, A being the moving power or weight of column of air in the downcast, B the weight of column in upcast, C the water gauge, and C' the power required to force the air over the furnace and up the upcast.

$$\text{Then, } A = BCC' \text{ and } C' = A - BC.$$

An examination of these diagrams will show the comparative increase of power required to force the air up the shaft, and that required to force the air around the workings, especially in the case of Tyne Main, where the velocity of the air through the cylinders of the steam jet was excessively great, nearly 64·5 feet per second, or 3,870 feet per minute. The power expended in forcing the air over the furnace and up the shaft being in this case greater than what was required to force the air around the workings, as will be seen on diagram, Plate IX.

I shall not pursue this part of the inquiry further at present, as the experiments, when closely examined, will, I trust, give all the information requisite for the object of this paper. This part of the subject is, however, of such great importance in the theory, practice, economy, and efficiency of mine ventilation, that I presume the Institute will not rest satisfied until it has made itself master of all the information requisite to a complete solution of the entire subject.

It is now necessary, before proceeding further, to notice an impression of some consequence, which was strongly urged before the Committee of the Lords in 1849, and which, if it had not been made the subject of investigation in this inquiry, might have received confirmation, and if so, would have produced an erroneous conclusion of the facts as regards coal mine ventilation. I allude to the supposition that the current of air in a mine requires some considerable period of time to be put in motion, or to be made to acquire its maximum velocity; and when in motion, that its momentum causes it to retain its velocity some considerable time after the impulsive power is withdrawn.

The following is one of many experiments made to determine this. In the experiment of November 13th, at Hetton Colliery, the furnaces were put out, the engine fires were damped, and the temperature of the air in the upcast reduced to 74°, and the quantity of air passing through the workings reduced to 80·182 cubic feet per minute. The furnaces were then lighted. The velocity of the current of air passing towards the furnace C, Fig. 3, Plate I, was measured by one of Biram's most improved 12-inch anemometers, within 50 yards of the furnace.

The time during which the vernier of the anemometer marked 1,000 feet was correctly noted, and the following was the result:—

NATURAL VENTILATION.

TIME.				TIME.		
H.	M.	S.		H.	M.	S.
3	48	47	Commenced experiment, temperature 75°.			
3	50	50	Four revolutions of anemometer = 4,000 feet, in - -	0	8	3
3	52	53				
3	54	52				
3	56	55				
			Applied the fire to the furnaces at 4 h. 3 min.			
4	8	55	Commenced experiment.			
4	9	57	Four revolutions = 4,000 feet, in - - - - -	0	4	3
4	10	57				
4	11	58				
4	12	58				
4	13	55	Four revolutions = 4,000 feet, in - - - - -	0	3	48
4	14	52				
4	15	50				
4	16	46				
4	17	42	Four revolutions = 4,000 feet, in - - - - -	0	3	34½
4	18	39				
4	19	34				
4	20	30½				

The

The water gauge also showed how rapidly the current increased in velocity:—

H.	M.	S.		*Inches.*
4	0	0	-	·45
4	3	0	-	·70
4	5	0	-	·90
4	6	0	-	1·
4	7	0	-	1·30
4	8	0	-	1·40
4	9	0	-	1·45
4	10	0	-	1·50
4	11	0	-	1·6
4	23	0	-	1·75

These results took place, the measurement of the air being taken near the furnace, *C*, Plate I. and the water gauge applied at the doors between the downcast, or air entering the workings, and the air returning from the workings, as at the doors, *a*, Fig. 1, Plate II. The quantity of air entering the mine was, however, measured every half hour at the respective downcast shafts, and the following was the result:—

Time.		East and West Minor.	Eppleton.	Elemore.	Total.
H	M.	Cubic Feet per Minute.	Cubic Feet per Minute.	Cubic Feet per Minute.	Cubic Feet per Minute.
3	30	80·182	46·400	5·563	127·145
4	30	138·353	62·640	10·200	211·193

The distance which the currents of air had to traverse between the respective downcast and upcast shafts, will be seen by an inspection of the table of the Hetton ventilation, Table I., Appendix.

The same comparative result took place on the application of the steam jets, 37 in number, ¼ inch diameter; steam 40 lbs. per square inch.

Steam blowing into Furnace Drifts.

H.	M.	S.	
11	50	25	Commenced experiment.
11	52	25	Three revolutions in 6 min., nearly 1,000 feet in 2 min.
11	54	30	
11	56	24	Jets set on.
11	58	1	Four revolutions in 6 min. 32 sec., or 1,000 feet in 1 min. 38 sec.
11	59	35	
12	1	11	
12	2	45	
12	4	33	

The effect, as shown by these experiments, and which was corroborated by several others, which it is not necessary to give here, shows, that it requires only a very short time indeed to put the entire current of a coal mine into its maximum velocity.

I shall now proceed to ascertain the relative power and efficiency of the different modes of ventilation, as elicited by the preceding experiments.

The following Tables show the general result of the experiments at Hetton, Killingworth, Tyne Main, and Norwood Collieries.

TABLE XXII.

General Result of the Experiments at Hetton Colliery.

DATE.	Natural Ventilation.		Engine Fires.		Engine Fires, and Steam.		Engine Fires Steam, and Jets.		Three Furnaces.		Three Furnaces, Engine Fires, and Steam.		Three Furnaces, Engine Fires, Steam, and Jets.	
	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.
1852:														
12 October	- -	- -	- -	- -	- -	- -	- -	- -	126°6′	187,580	148°7′	198,261	—	—
29 „	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	180	205,615	—	—
29 „	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	180	201,274	180°	205,636
30 „	- -	85°	130,890	- -	- -	98°	139,176	105°	149,284	—	—	—	—	—
30 „	- -	- -	- -	- -	- -	- -	- -	105	150,873	- -	- -	- -	164	207,093
31 „	- -	85	104,414	- -	- -	- -	- -	- -	- -	167	201,960	—	—	—	—
3 November	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	168	208,443	180	212,907
13 „	- -	80	123,463	89°	132,053	91	139,847	94	164,376	178	211,193	—	—	—	—
13 „	- -	68	127,145	- -	- -	- -	- -	- -	- -	211	225,176	226	229,918	229	234,118
		80°	121,478	89°	132,053	94°5′	139,512	101°5′	166,133	170°6′	206,477	180°5′	208,702	188°	214,938
										One Furnace.				One Furnace and Jets.	
11 December	- -	73°	117,908	81°	121,464	82°	129,569	88°7′	146,010	95°	166,826	- -	- -	124°	194,075

TABLE XXIII.

General Result of the Experiments at Killingworth Colliery.

DATE.	Natural Ventilation.		Steam alone.		Jets and Steam.		Furnace alone.		Furnace, Jets, and Steam.		
	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	
1852:											Jets at bottom of Pit:
15 November	- -	8,888	- -	- -	90°	16,570	92°	24,625	- -	- -	Regulator, 3 ft. 10 ⅞ in. × 5ft. 6 in. also other regulators in.
19 „	95°	8,494	98°	16,134	90	16,259	- -	- -	- -	- -	Regulator 1 ft. 2 ⅜ in. × 5 ft. 6 in. other regula. out.
19 „	- -	- -	102	20,708	102	24,164	133	26,774	- -	- -	Regulator 4ft. 0 in. × 5ft. 6in. other regula. out.
20 „	- -	- -	- -	- -	144	29,752	122	24,220	151°	31,661	Ditto - ditto - ditto.
2 December	71	14,904	112	32,056	107	35,523	- -	- -	- -	- -	Cylinders in ditto - ditto.
2 „	- -	- -	- -	- -	- -	35,347	160	38,360	183	44,150	Cylinders out ditto - ditto.
4 „	65	9,176	88	28,888	101	32,500	147	37,741	164	44,570	Ditto - ditto - ditto.
10 „	- -	11,249	- -	- -	77	23,018	132	33,428	161	37,707	Jets at top of pit, cylinders in.
Result: 2 & 4 December	68°	12,040	100°	30,472	104°	34,456	153°5′	38,050	173°5′	44,360	Jets at bottom of pit.
					Jets only.				Furnace and Jets.		
10 December	65°	11,249	- -	- -	77°	23,018	132°	33,428	161°	37,707	Jets at top of pit.

TABLE XXIV.

General Result of the Experiments at Tyne Main Colliery.

DATE.	Natural Ventilation.		Jets alone.		Furnace alone.		Furnace and Jets.		REMARKS.
	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	Temperature.	Cubic Feet per Minute.	
1853:									
14 January -	62°	34,955	62°	47,120	160°	91,495	198°	104,052	Jets at top of pit, with cylinders.
15 „ -	62	36,873	62	49,576	262	102,503	272	106,880	Jets at top of pit, with cylinders.
28 „ -	62°5	39,576	62°	47,417	- -	- -	- -	- -	Jets at top of pit, without cylinders.
Average - -	62°	35,914	62°	48,348	211	97,000	235°	105,441	Jets at top of pit, with cylinders.
Norwood Colliery:									
1852:									
10 August -	- -	- -	- -	9,690	- -	- -	- -	- -	Jets 180 feet below surface.
12 „ -	98°	2,880	98°	6,000	98°	7,200	- -	- -	Jets 180 feet below surface.
			98	8,000	94	8,472	98°	9,000	Jets 180 feet below surface.
13 „ - -	- -	- -	- -	- -	100	9,600	112	11,064	Jets 180 feet below surface.
Average - -	98°	2,880	98°	7,896	97°2′	8,424	105°	10,032	

The following Table is the Mean Result of the Experiments made at Hetton Colliery:—

TABLE XXV.

DESCRIPTION OF POWER.	Mean Temperature of Upcast.	Cubic Feet of Air per Minute.	Increase.	
			Temperature.	Cubic Feet of Air per Minute.
Natural ventilation - - - -	80°	121,478	—	—
Engine fires - - - - -	89	132,053	9°	10,575
Ditto - and steam - - -	94°5	139,512	5°5	7,459
Ditto - - ditto - and jets - -	101°5	166,133	7	26,621
Three furnaces - - - - -	170°5	206,477	69	40,344
Ditto - - engine fires and steam -	180°5	208,702	10	2,225
Ditto - - ditto - - and jets -	188	214,938	7°5	6,236

The following Table are the Experiments made with One Furnace, 11 December 1852:—

TABLE XXVI.

DESCRIPTION OF POWER.	Mean Temperature of Upcast.	Cubic Feet of Air per Minute.	Increase.	
			Temperature.	Cubic Feet of Air per Minute.
Natural ventilation - - - -	80°	117,908	—	—
Engine fires - - - - -	81	121,464	1°	3,556
Ditto - and steam - - -	82	129,569	1	8,105
Ditto - ditto - and jets - -	88°7	146,010	6°7	16,441
One furnace - - - - -	95	166,826	6°3	20,816
One furnace and jets - - - -	124	194,075	29	27,249

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The following Table is the Mean Result of the Killingworth Experiments:—

TABLE XXVII.

DESCRIPTION OF POWER.	Mean Temperature of Upcast.	Cubic Feet of Air per Minute.	Increase.	
			Temperature.	Cubic Feet of Air per Minute.
Natural ventilation - - - -	68°	12,040	—	—
Steam alone - - - - -	100	30,472	32°	18,432
Jets and steam - - - - -	104	34,456	4	3,984
Furnace - - - - - -	153°5	38,050	49°5	3,594
Furnace, steam, and jets - - -	173°5	44,360	20	6,310

And the following Table is the Mean Result of the Experiments at Tyne Main:—

TABLE XXVIII.

DESCRIPTION OF POWER.	Mean Temperature of Upcast.	Cubic Feet of Air per Minute.	Increase.	
			Temperature.	Cubic Feet of Air per Minute.
Natural ventilation - - - -	62°	35,914	—	—
Jets - - - - - - - -	62	48,348	- - -	12,434
Furnace - - - - - - -	211	97,000	149°	48,652
Furnace and jets - - - -	235	105,441	24	8,441

I shall now endeavour to elucidate the practical results exhibited by these experiments; and, first of all—

Natural Ventilation.

On an examination of the tables and diagrams, it will be seen that the amount of natural ventilation is very considerable, amounting, in the case of Hetton, to one-half of the most vigorous ventilation produced; at Killingworth to nearly one-third; and at Tyne Main Colliery to fully one-third. The general temperature of the return air at Hetton is 69°, so that the mean temperature was 11° above that which the natural ventilation would produce in the shaft, leaving 104,775 cubic feet per minute due to a temperature of 69°. At Killingworth the mean temperature of the return air was 60°, showing 8° less than the temperature in the shaft, and leaving 10,623 cubic feet per minute for natural ventilation. Hetton, arising from the upcast not being cooled down sufficiently, and Killingworth from the heat given out by the steam pipes passing down the shaft. Tyne Main, the temperature in the shaft and of the return air was precisely the same; and, therefore, it was an accurate experiment of the amount of natural ventilation on the day the experiment was made, amounting to nearly 36,000 cubic feet per minute.

I have, however, previously remarked, that natural ventilation is not to be depended upon; that the amount will vary as the temperature on the surface varies, the temperature in the mine not varying very materially in the different seasons of the year. It is necessary, therefore, that this should be attended to in the practical ventilation of the mine, and, if furnaces are used, that a more vigorous combustion should be urged in summer, to make up for the diminution of weight of the downcast air by its increased temperature; and that if the steam jet or mechanical power is applied, that they should be made to act more powerfully in summer than in winter.

The next description of power to be considered is, the

Boiler Fires, or Engine Fires.

The only place where this was experimented upon was at Hetton, where the boilers are placed at the bottom of the pit; at Killingworth and Tyne Main the boilers were on the surface. The heat of the boiler fires, as measured by the temperature of the air in the shaft, acts precisely in the same manner as the furnace, by increasing the temperature, and so diminishing the weight of the column of the upcast shaft. I shall afterwards go into the question of the comparative consumption of coals between the engine fires and the furnace, in producing the same temperature in the shaft; the question at present being as to the comparative efficiency of ventilation of the column of air in the upcast shaft, heated by natural heat, and by the heat from the engine fires, or the additional amount of ventilating power by the engine fires over the natural ventilation. We have, in Table XXV., an addition of 10,575 cubic feet per minute by the boiler fires over natural ventilation, and we have 121,478 cubic feet of air produced by a temperature of 80°, or 1,518 cubic feet

feet for each degree, with natural ventilation; and with the engine fires, 132,053 with 89°, equal to 1,483 cubic feet for each 1°; the additional quantity of air, in this latter case, showing an increased resistance. If we, however, take the latter case, then 9° should have produced 9° × 1,483 = 13,355 cubic feet of air, whereas it only produced 10,575 cubic feet, or 1,175 cubic feet for each degree of temperature; the conclusion being, that the smoke from the engine fires adds to the density of the column in the upcast shaft beyond that of a column of equal temperature heated by the natural heat of the mine.

We have next,

Engine Fires and Steam.

In the Hetton Experiments, Table XXV., the increase by 5°·5 of temperature over the engine fires was 7,459 cubic feet of air, or 1,356 cubic feet of air for 1°, which is greater than the quantity for each degree produced by the engine fires, though a still further increased resistance has to be overcome, by the increased velocity of the air. But in this case the steam is mixed up with the smoke from the engine fires, and it is difficult to determine what is due to each, although this experiment is sufficient to show that the steam, by presenting a column of less specific gravity than the engine fires, produces an increased effect.

The experiments at Killingworth, Table XXVII., are, however, more decisive. In this case, the steam was applied, in addition to the natural heat, without any smoke, the boilers being at bank, and the steam conveyed to the bottom of the pit in pipes.

The natural heat of 68° gave 12,040 cubic feet per minute, or 177 cubic feet of air for one degree; and the steam, with a temperature of 100°, produced 30,472 cubic feet of air, or 304 cubic feet of air for each degree of temperature, though the increased quantity of air increased the resistance, the water-gauge being in the former case 1·50 lbs. per square foot, and in the latter 3·30 lbs.

This will also be seen on a reference to the experiment on December 4th, and to Diagrams V. and VIII., representing that experiment. It will be seen, also, that the resistance in the shaft is less with the steam than by natural ventilation, in the proportion of ·38 to 1·02. We thus see, what an important element of ventilation steam is, applied at the bottom of the pit, and how likely we are to be deceived in the power of the steam jet by not taking that element into consideration.

The value of steam as a ventilating power, independently of being used as jets, is shown by a careful examination of these experiments. In the Killingworth Experiments, Table XXVII., the steam heated 30·472 cubic feet of air 32°, or, 975·104 cubic feet of air 1°; we can thus ascertain the economy of employing steam in this manner. The quantity of steam used could not, in this experiment, be correctly ascertained, but three boilers were at use in the manner described in Plate II., evaporating upwards of 2 ½ cubic feet of water per minute, the steam being conveyed down the pit by a pipe 10 inches diameter, and the steam being kept blowing off into the shaft at 40 lbs. pressure per square inch during the experiment; the quantity was sufficient to keep 29 jets ⅝th inch diameter, or an area of 1,423 inches, supplied with steam, as shown in Plate II., Figs. 2 and 3, at 40 lbs. per square inch.

We now come to the application and performance of the steam jet as a propulsive power, above that due to the rarefaction by the heat of the boiler fires, and of the steam in the upcast shaft.

Steam Jets.

I shall take the case of the application of the jets at Tyne Main Colliery first, as being applied at the top of the pit, and as acting solely as a propulsive force, and not being affected by the heat of the engine fires, or of the steam in the shaft. In this case, the temperature of the air in the upcast shaft was precisely the same, when the current of air was produced by the natural heat of the mine, and during the application of the steam jet; so that, on this account also, the jets were not affected by the heat of the shaft. Fig. 8, Plate II., shows the mode of application at the top of the pit, 60 feet from the top of the shaft A, and level with the surface. Fig. 11 shows the jets, 61 in number, ⅝th inch diameter each, = 1,684 inches area; cylinders being placed over the jets, and the interstices between the cylinders made quite air-tight, so that the whole of the air and steam had to pass through the cylinders; and this was the case with the natural ventilation, and also when the furnace was applied, the area through the cylinders being 40,258 square feet. The area of the shaft itself for 102 feet midway down being 44·18 square feet, and above and below that 50·257 square feet; so that we had 6 feet 40·258; 102 feet, 44·18; and 564 feet, 50·257 square feet area.

Table XXVIII. shows the natural ventilation 35·914 cubic feet per minute, and the jets 48·348, leaving 12·434 cubic feet as the propulsive force of the jets; the temperature of the air in the upcast shaft remaining the same during the experiment. No more conclusive experiment could be made than this to determine the impulsive power of the jets when placed at the top of the pit. The water gauge, showing the force required to propel the air through the workings, was 2·4 lbs. per square foot.

Table XXIII. shows the result at Killingworth, when the jets were placed at the top of the pit. The natural ventilation was 11·249 cubic feet per minute. With the jets the quantity was 23·118, leaving 11·769 cubic feet for the jets only, although the temperature was raised in the shaft from 65° to 77°, which ought to have given 2,280 cubic feet; the jets in this case realising, therefore, only 9·489 cubic feet per minute. The water gauge in this case was 2·1 lbs per square foot, the area of the jets being 1·423 inches.

Table XXV. gives the result at Hetton, and shows an increase of ventilation by the jets of

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26·621 cubic feet per minute; but the increase of temperature being 7°, which would give $\frac{166·133}{101·5}\ 7° = 11·522$, and which, deducted from 26·621, leaves 15·099 cubic feet per minute as the effective impulsive power of the jets; the water gauge in this case being about 5·13 lbs. per square foot, and the area of the jets 1·816 inches.

It must be observed, with reference to a comparison of these results, that the resistance of the air in the shaft, or through the jets, in each case must be taken into consideration. In the experiment at Tyne Main, the velocity through the cylinders was 21·11 feet per second, and at Killingworth 19·96 feet per second. At Tyne Main, the area of jets was 1·684 square inches, and at Killingworth 1·423 square inches. Taking all these into consideration, the correspondence between these experiments will be seen to be very near; and therefore we may take the Tyne Main experiment as a standard for the propulsive power of jets, placed at the top of the pit; viz., that steam of 40 lbs. per square inch pressure, applied to jets, of an aggregate area of 1·684 square inches, at the top of the upcast shaft, will produce an amount of ventilation equal to 12·400 cubic feet of air per minute, the water gauge being 2·4 lbs per square foot, and the resistance up the shaft 2 lb. per square foot, when the velocity through the cylinders is not greater than 21 feet per second. And we may add, that this result will require an evaporation of about 1·8 cubic feet of water per minute without waste, reckoning the velocity of the steam through the jets at 1,080 feet per second, or, as per experiment, 1·83 cubic feet per minute, allowing for waste.

It has been stated recently, by the advocates for the steam-jet, that the top of the pit is not the proper place to apply it, and that it should be applied at the bottom of the pit. No doubt, when placed at the bottom of the pit, we have the advantage of the rarefaction of the boiler-fires and steam. But the question before us at present is, do the jets realise a greater impulsive force when placed at the bottom, or when placed at the top of the pit?

The experiment, given in Table XXIII., at Killingworth, was made to determine this. From this table it will be seen that the effect of the jets over the natural ventilation was 22,416; viz., 34,416—12,040 cubic feet per minute, when the jets were placed at the bottom of the pit. The increased temperature, however, was from 68° to 104°. Then $\frac{34,456}{104°} \times 36° = 11,926$ cubic feet of air due to temperature; and, therefore, $34,456 - 12,040 + 11,926 = 10,490$ cubic feet per minute due to the impulsive power of the jets, *when placed at the bottom of the pit.* Then, December 10th, 23,018—11,249 = 11,769 cubic feet over natural ventilation; but the temperature was increased from 65° to 77°, therefore $\frac{23,018}{77°} \times 12° = 3,576$; and 11,769 — 3,576 = 8,193 cubic feet per minute, the impulsive power of the jet, *when placed at the top of the pit.* It must, however, be taken into account, that when the jets were placed at the bottom of the pit, the openings around the jets or cylinders were not closed, and that the area of the space through which the air and steam had to pass was about 30 feet; whereas, when the jets were placed at the top of the pit, the air and steam had to pass through the cylinders of an area of little more than 19 square feet. Unless, therefore, the jets could be applied so that the resistance should be the same in both cases, the experiments would not be parallel. It is evident, however, that the bottom of the pit is the proper place to apply the jets, as in that case the effect of the boiler fires and the steam will likewise be made available. There does not, however, appear to be any great difference in the mechanical effect, whether the jets are placed at the top or bottom of the pit. If we take the case of Hetton and Killingworth at the bottom of the pit, and Tyne Main at the top, the following will be the comparative results:—

COLLIERIES at which Experiments were made.	Velocity of Air through Cylinders or Upcast Shaft.	Pressure of Steam per Square Inch.	Area of Steam Jets in Inches.	Cubic Feet per Minute of Air.	Position of Jets.
	Ft. per min.				
Hetton - - -	1,061	40	1,816	15,099	Bottom of pit.
Killingworth - -	1,083	40	1,423	10,490	
Tyne Main - -	1,239	40	1,684	12,400	Top of pit.

We see, therefore, that there is no great difference, if any at all, in the *impulsive* force of the jets, whether placed at the top or bottom of the pit, and that the result of the experiment at Tyne Main Colliery, as given above, and the average of Hetton and Killingworth, may be taken as a standard of the impulsive force of the jets, which is about 12,500 cubic feet per minute; area of jets, 1·64 inches; steam at 40 lbs. pressure per square inch; water gauge about 4 lbs. per square foot. Let us now see the power applied, and the effective performance. The evaporation of water at Tyne Main was 1·82 cubic feet per minute, × 506 = 921 cubic feet of steam at 40 lbs. pressure per square inch. Area of shaft, 40,258 square feet. Then $\frac{921}{40·258} = 22·77$ cubic feet of steam per minute for each foot area of shaft, at 40 lbs. pressure per square inch. But the velocity of the air in the shaft is $\frac{49·574}{40·258} = 1231·4$ feet

feet per minute. Then as 22·77 : 1231·4 : : 40 : : ·7396 lbs. per square inch on each foot of surface of the shaft, moving at the rate of 1231·4 feet per minute, or ·7396 × 144 = 106·5 lbs. per square foot, moving at the rate of 1231·4 per minute. Then $\frac{106{\cdot}5 \times 40{\cdot}258 \times 1231{\cdot}4}{33{\cdot}000}$ = 160 horses' power, the power employed.

It is difficult to ascertain the precise effective performance; we have the water gauge equal to 2·4 lbs per square foot, but we have no measure of the resistance of the air in the shaft and through the cylinders; supposing, however the dotted line, Plate IX., to represent these, being what would be the resistance if the furnace had been employed, it would be 2 lbs. per square foot, and this would represent $\frac{4{\cdot}4 \times 40{\cdot}258 \times 1231{\cdot}4}{33{\cdot}000}$ = 6·6 horses' power, effective performance.

This very enormous loss of power seemed quite unaccountable, and I therefore instituted a set of experiments, with a view of endeavouring, if possible, to ascertain the cause. I have previously stated that the Killingworth Pit is divided into four compartments, by air-tight timber brattices or partitions; one of those partitions formed the downcast, and the adjoining one the upcast, in the experiments at that colliery, shown in Fig. 6, Plate II. It occurred to me, if I could ascertain the density or degree of rarefaction of the air in the upcast at all the different depths, as compared with that of the downcast at the same depths, when the different modes of ventilation were in operation, it might throw some light upon the matter. For this purpose I had holes bored through the brattice or partition between the downcast and upcast divisions of the shaft, at every 60 feet in depth from the surface to 600 feet, and then at every three feet from 600 feet to the bottom of the pit, into which I inserted the water gauge, in the same manner as shown in Fig. 1, Plate II. (the door in this case representing the division between the two columns of air), and in this manner I obtained the comparative density of the two columns of the downcast and upcast shafts, at the various depths, when the different modes of ventilation were in operation.

The following Table will show the result:—

TABLE XXIX.

EXPERIMENTS on the DENSITY OF THE AIR in the Upcast Shaft at Killingworth.

Depth of Shaft, in Feet.	Height of Water Gauge, in Inches.				
	Natural Ventilation.	Steam.	Jets, Bottom of Pit.	Furnace.	Jets, Top of Pit.
60	·025	·07	·05	·10	·10
120	·025	·10	·08	·115	·20
180	·075	·12	·12	·13	·275
240	·15	·20	·18	·20	·3
300	·25	·26	·25	·25	·35
360	·25	·28	·28	·35	·325
420	·25	·34	·30	·45	·3
480	·25	·45	·34	·57	·325
540	·25	·50	·375	·70	·35
600	·25	·60	·40	·78	·35
603	·25	·60	·42	·76	·35
606	·25	·62	·50	·78	·375
609	·25	·60	·45	·76	·375
612	·25	·60	·45	·80	·375
615	·25	·62	·45	·78	·375
618	·25	·62	·475	·77	·40
621	·25	·63	·45	·77	·4
624	·25	·63	·50	·70	·375
627	·25	·63	·50	·73	·375
630	·25	·65	·50	·70	·375
633	·225	·62	·55	·67	·35
636	·225	·64	·55	·68	·35
639	·20	·61	·60	·70	·35
642	·20	·63	·75	·70	·35
645	·20	·60	·70	·70	·325
648	·225	·60	·72	·75	·3
651	·225	·50	·70	·77	·35
654	·20	·58	·675	·76	·3
657	·20	·60	·675	·70	·325
660	·20	·60	·55	·74	·3
663	·20	·60	·50	·78	·3
666	·20	·60	·55	·80	·325

Appendix, No. 1.

For the more clearly exhibiting the effect of the different moving powers, I have made two diagrams, Plates X. and XI. It will be seen that below 600 feet the water gauge was taken every three feet; this was done to show more clearly the effect in the immediate vicinity of where the jets and furnace were applied, and the result will be found interesting.

It must, however, be observed, that these diagrams do not exhibit the actual degrees of rarefaction in the upcast shaft, but the comparative densities only between the air in the downcast and the upcast shafts, at the various depths; the comparative areas of these diagrams, however, show generally the comparative ventilating powers of the different modes.

On a careful examination of these diagrams, it will be seen that the natural ventilation presents a column of nearly uniform density throughout; near the top of the pit the relative densities may be discarded. The steam is the same, especially in Plate XI., only showing by its increased bulk the comparative elasticity of the column. The furnace diagram shows an increased rarefaction in Plate XI., where the heated air enters the shaft, and for a considerable distance up the shaft in Plate X., when it gradually diminishes as the depth from the surface becomes less. The steam jets at the bottom of the pit exhibit a considerable increase of effect a little below and immediately above the jets, as much as the furnace, but in a short distance it falls off, and the column gradually diminishes like the others; but it is to be remarked, that though the quantity of steam issuing from the jets was the same, the column No. 3 of the steam jet is much more dense above 600 feet from the surface than the steam No. 2, showing an increase of effect at and near the jets, but a loss of effect in the upper part of the column. I had supposed, seeing that the effect both of the furnace and the jets diminished towards the upper part of the column, that the application of the jets at the top of the pit would have compensated for this, and by exhausting the upper end of the column we should have had a much greater combined effect, when we had the jets at the top drawing out the air at one end of the column, and the rarefying power of the furnace acting at the other end; and the result showed that such an effect did to a certain effect take place. It will be seen that in No. 5, with the jets at the top of the pit, an increase of effect is obtained for at least half-way down the shaft, when the effect falls off, and diminishes much below that of the steam alone, but still nearly equal to the jets placed at the bottom of the pit, except in their immediate vicinity, and within the operation of their impulsive power.

The diagram of the jets shows pretty clearly the operation of the application of this power. Immediately below where the jets are applied an increase of effect takes place, shown by the increased rarefaction of the column, and produced, of course, by the propulsive force of the jets acting on the column above, and creating a partial vacuum or rarefaction, into which the air from below rushes. [This was shown also by some experiments at Tyne Main Colliery, by placing the water gauge with one end of the tube within the upcast, and the other end communicating with the outer air. The water gauge immediately below the jets was ·24 to ·275 of an inch, and immediately above the jets ·18 to ·2 of an inch. The water gauge at the furnace doors ·2 natural ventilation, and ·325 to ·4 when the jets were applied.] Immediately above the jets an increased effect is likewise seen; but this only takes place for a comparatively short distance above the jets, when such effect of, in fact, pushing up the column, appears to have the tendency to compress the column above, and thus to exhaust its power, and so produce a comparatively feeble effect.

When the jets are placed at the top of the pit, it has also been deemed necessary to apply cylinders, and to close all the openings or interstices around the cylinders, to prevent eddies or any air from being drawn down the shaft, and so to repass through the cylinder, to the exclusion of the air up the shaft. On examining the experiments made at Killingworth, Tables IX., X., and XI., it will be seen that no such action takes place, and that no sensible advantage is obtained by having the jets placed within cylinders, whether the jets are placed at the top or at the bottom of the pit; the shaft itself forming, indeed, the cylinder or chimney for the aggregate number of jets, in place of one cylinder for each jet. This will also be seen by an inspection of Tables XXIII and XXIV.

Having thus shown the particular action of the jet, I shall now again revert to its mechanical effect in producing ventilation. I have given a standard of its power when employed solely as a ventilating force; another mode of application is that of its being employed as an auxiliary to the furnace, and on an examination of the experiments, it will be seen that its power has been tested in this respect in a variety of cases, the results of which are given in the different tables, and are likewise shown in the diagrams.

When employed alone, or solely as a ventilating power, with two or three boilers, the power is much below that of the furnace, the water gauge not reaching beyond 4 lbs per square foot, or, in extreme cases, 6 lbs. per inch; while with the furnace, a water gauge of 12 lbs. per square foot has been reached. When the jets are therefore to be applied as an auxiliary to the furnace, they will have to operate upon an increase of resisting medium, of, in fact, a water gauge of double the amount of that which they are capable of reaching when applied alone.

If therefore we find the jets, applied alone, to produce a water gauge of 4 lbs. per square foot, or 12,000 cubic feet of air, and they are to be applied as an auxiliary to the furnace, they have then to encounter a water gauge of 12 lbs. per square foot; and then the same power, which at a water gauge of 4 lbs. per square foot produced 12,000 cubic feet of air, will, with 12 lbs. of water gauge, only produce 4,000 cubic feet of air,—and in this case the jets have to encounter another disadvantage, in the increased velocity of the air on which they have to impinge.

Previously, however, to arriving at any conclusion as to the effect of the jets as an auxiliary

auxiliary to the furnace, it will be necessary, first of all, to investigate the power of the furnace as a ventilating force. Appendix, No. 1.

Furnace Ventilation.

The experiments with the furnace, in its full vigour of action, as a ventilating power, were made at Hetton and Tyne Main; the experiments at Killingworth and Norwood, and also some of the experiments at Hetton, were made to compare the relative powers of the jets and of the furnace, by an application of the latter in a diminished power, or as nearly equal to the power of the jets as possible.

Taking the experiments at Hetton, and referring to the general result, Tables XXV. and XXVII. we find the furnaces producing an increased ventilation of nearly 80,000 cubic feet of air per minute over that of the natural ventilation, and 40,344 cubic feet above that of the natural, engine fires, steam, and jet ventilating powers. And at Tyne Main Colliery 61,000 cubic feet above the natural ventilation, and 48,652 above that of the jet ventilation. It is unnecessary to do more than to refer to these experiments (authenticated as some of them were by the presence of several of the Government Inspectors of Coal Mines, and also by a great many of the viewers and mining engineers of the trade), to show, that when furnace ventilation is pushed to its maximum working effect, no application of steam jet yet applied has reached within a considerable distance of the effective performance of its powers.

The highest water gauge reached by the jets at Hetton Colliery was 5·13 lbs. per square foot, while the furnaces produced 12 lbs per square foot; more than double the power. At Tyne Main the water gauge by the jets was 2·4 lbs. per square foot, and that by the furnace 7·2 lbs., three times the power.

So far, therefore, as regards the application of the steam jet as a *substitution* of the furnace, and considered with reference to their comparative powers, in producing the largest amount of ventilation, and, consequently, as having a tendency in that respect to prevent accidents in coal mines, these experiments show, in the most conclusive manner, that the steam jet, as hitherto employed, is far inferior to the furnace in producing the largest amount of ventilation in deep mines; and the experiments at Norwood Colliery show, that with equal areas of fire grate, the furnace is also superior to the steam jets in shallow mines.

I shall now consider the steam jet as an *auxiliary* to the furnace, and it is in this capacity that it would appear, at first sight, to be available, if available at all. In the above remarks, I have confined myself to their comparative powers solely as mechanical forces in producing ventilation. I shall afterwards go into their relative economy, and in the investigation of the application of the steam jet as an auxiliary to the furnace. I shall confine myself to the result deduced by these experiments, without indulging in any speculation, or probable increase of powers or improvements, to be hereafter realised, whether it may apply to the one power or to the other.

In arriving at a practical conclusion, as to the power of the jets as an auxiliary to the furnace, it will be necessary, first of all, to consider more particularly the power and efficiency of the furnace, as deduced from these experiments.

In the case of the Hetton Colliery, the aggregate result of these experiments, Table XXV., shows the "natural ventilation" as equal to 121,478 cubic feet per minute, the temperature in the upcast shaft being 80°. And when the furnaces were applied, and the temperature raised to 170°5, the ventilation was 206,477 cubic feet per minute, or 40,344 cubic feet per minute above the effective performance of the jet, although, in the latter case, the jet had the advantage of the rarefaction of the heat from the boiler fires, and from the steam issuing from the jets. At Tyne Main, Table XXVIII., the effect was 97,000, or an increase above the jets of 48,652 cubic feet per minute.

The experiments represented in diagrams, Plates IV. and VI., and Plates VII. and IX., also show the comparative power of the furnace and steam jets in the most conclusive manner.

In the Hetton experiments, Plate VII., the effective performance of the furnace is 225,176 cubic feet of air per minute, or $11{\cdot}70+6{,}518 = 18{,}218$ lbs. pressure per square foot area of the shaft, at a velocity of $\frac{225{,}176}{153} = 1{,}475$ feet the minute; and consequently $\frac{18{,}218\times1{,}475\times153}{33{,}000} = 124{\cdot}6$ horses' power.

The effective performance of the jets was 164,000 cubic feet of air per minute, or $5{\cdot}13+4{\cdot}7 = 9{\cdot}83$ lbs. pressure per square foot area of shaft, at a velocity of $\frac{164{,}000}{153} = 1{,}072$ feet per minute; and consequently $\frac{9{\cdot}83\times1072\times153}{33{,}000} = 48{\cdot}86$ horses' power. But to obtain the performance of the jets as a mechanical or propulsive force, we must deduct the effect of the engine fires and steam, which was $3{\cdot}6+2{,}675 = 6{\cdot}275$ lbs. per square foot of shaft. Then $\frac{139{,}847}{153} = 914{\cdot}1$ feet per minute, and $\frac{6{,}275\times914{\cdot}1\times153}{33{,}003} = 26{\cdot}6$ horses' power deducted from 48·86, leaves 22·26 horses' power as the effective performance of the jet, though the increased temperature above that of the engine fires ought also to be deducted. This gives the relative performances as 124·6 : 26·6 for the furnace and jets, the water gauge being 5·13 lbs. per square foot. And this result, as will hereafter be seen, is that of three furnaces consuming under 20 lbs. of coal per minute, the jets requiring 25 lbs. per minute; and the latter with an evaporation of 1·55 cubic feet of water per minute, applied in 37 jets, $\frac{5}{8}$ths of an inch diameter, or an area of 1·816 inches, with steam at 40 lbs. per square inch, applied at the bottom of the pit.

Appendix, No. 1.

The experiment at Tyne Main, represented in Plate IX., will show that the furnace ventilation was 7·2+8·477 = 15,677 lbs. pressure per square foot area of shaft, at a velocity of $\frac{102{\cdot}503}{50{\cdot}257}$ = 2039·8 feet per minute—and $\frac{15{,}677\times2039{\cdot}1\times50{,}257}{33{,}000}$ = 48·7 horse power.

The steam-jet performance was 2·4+2 = 4·4 lbs. pressure per square foot area of shaft, at a velocity of $\frac{49{\cdot}574}{50{\cdot}257}$ = 986·4 feet per minute—and $\frac{4{\cdot}4\times986{\cdot}4\times50{,}257}{33{,}000}$ = 6·6 horses' power.

Consequently the relative effective performance at Tyne Main Colliery is as 48·7 : 6·6 for the furnace and jets; the furnace consuming about 16 lbs. of coal per minute, and the jets 21 lbs., with 61 jets $\frac{3}{16}$ths of an inch diameter, or 1,684 inches area. Steam 40 lbs. per square inch, applied at the top of the pit, and with an evaporation of 1·82 cubic foot of water per minute.

On comparing these results, it will be seen that the experiment at Tyne Main Colliery shows a greater comparative result, as regards the furnace, than Hetton. It must, however, be taken into consideration, that the furnaces at Tyne Main were urged with more vigour than Hetton, the temperature of the air in the upcast with the former being 262°, and in the latter 211°, though the evaporation of water at Hetton, with the jets, was 1·55, while at Tyne Main it was 1·82 cubic feet per minute.

These experiments were made to test the absolute comparative power of the two systems, Those at Killingworth, and with one furnace at Hetton and at Norwood, were made to test their comparative economy when the powers were as nearly equal as possible, and which I shall go into hereafter.

The object, in this stage of the inquiry, being to ascertain if the steam jet is capable of a greater performance than the furnace, and if it can be applied as a substitution of the furnace, so as to produce a more powerful ventilating force, and so render the mines more safe.

The result at Hetton would show, that in order to produce an equal effect with the jets as with the furnaces, the power of the jets would require to be increased in the ratio of 124·6 : 26·6 exclusive of the effect of the heat of the engine fires and steam; and at Tyne Main in the ratio of 48·7 ; 6·6, supposing no loss of power takes place with the jets when the velocity of the air which they have to propel is increased. The velocity of the air propelled by the jets at Hetton was 914 feet per minute, while it was 1,072 feet per minute when the furnace was applied ; and at Tyne Main, with the jets 986, and with the furnace 2,039 feet per minute.

Sufficient, therefore, appears to be shown by these experiments, that as a substitution for the furnace there would require to be a very great increase in the consumption of coals, in the application of the jets, to reach the same ventilating power as the furnace; that as a *substitution* its application is inadmissible; and that the only mode in which the jet can be applied, if applied at all, is as an *auxiliary* to the furnace, and in this capacity we shall now proceed to investigate its efficiency.

Furnace and Steam Jets.

Diagram, Plate VII., shows the increase of ventilation of the steam jets in addition to the furnaces, and which is 7,249 cubic feet per minute; but, it will be observed, that the temperature was increased from 226° to 229°, or 3°. This must therefore be taken into account. The furnace and engine fires gave 229,918 cubic feet per minute, the temperature being 226_0. Suppose the same effect to take place by an increase of 3° beyond 226°, we have $\frac{229{,}918\times3^\circ}{226^\circ}$ = 3,052, which, deducted from 7,249, leaves 4,197 cubic feet per minute due to the propulsive power of the jets, the velocity of the air on which they impinged being 2,094 feet per minute.

Again at Killingworth, diagram, Plate VIII., the increase was 6,859 cubic feet per minute, the increase of temperature being 17°. Then $\frac{37{,}741\times17^\circ}{147^\circ}$ = 4,364, which, deducted from 6,859, leaves 2,495 cubic feet per minute due to the impulsive power of the jets, the velocity of the air on which the jets acted being 1,815 feet per minute.

The jets in both of these cases were applied at the bottom of the pit. We have no means, as before stated, of ascertaining the precise resistance of the air in the shaft when the jets are applied; but, taking the water gauge, as a measure of the efficient practical effect of the jets in the different modes of application, we have, as the impulsive powers of the jets,—

	JETS ALONE.		FURNACE AND JETS.	
	Cubic Feet of Air per Minute.	Water Gauge in Lbs. per Square Foot.	Cubic Feet of Air per Minute.	Water Guage in Lbs. per Square Foot.
Hetton Colliery - -	15,099	5·13	4,197	12·38
Killingworth Colliery -	9,489	2·1	2,495	7·5

Showing

Showing a diminution of effect, when the velocity of the air on which the jets act is increased, and certainly a very small effect in addition to the furnace, considering that a quantity of steam issuing out of an aggregate area of 1·8133 inches at 40 lbs. pressure per square inch, and an evaporation of 1·55 cubic feet of water per minute, was employed a Hetton, and steam at 40 lbs. pressure per square inch, with an area of jets of 1·423 inches, was employed at Killingworth.

There are also several other allowances to make, if these experiments were strictly construed, which would diminish the comparative result of the jets; but, as before stated, my object being to show the result in a practical manner, I have abstained from going into the subject in a close, theoretical, or abstruse character; the experiments, however, are furnished in such a manner, that this can be gone into by any one, and on a future occasion, and the details will, of themselves, be found to be sufficiently interesting and useful.

I shall now give the result of the experiments made to ascertain the comparative economy of the two systems, as regards the consumption of coals or power employed, and the corresponding effective performance produced.

For this purpose, the entire furnace ventilation power of Hetton Colliery was made the subject of experiment for 24 hours consecutively, the jet ventilation at Hetton was made the subject of experiment for 12 consecutive hours; and, that the comparison between the furnace and jets should be made the subject of experiment, under as precisely the same circumstances, or as nearly equal power as possible, two of the Hetton furnaces were extinguished, and an experiment for 12 hours was made on the ventilating power of one furnace to compare with the jets.

Similar experiments were made at Tyne Main Colliery, to ascertain the relative economical performances of the furnace and steam jets.

The details of the Hetton experiments are given in Tables V., VI., VII. and VIII.; and the experiments at Tyne Main, in Tables XII. and XVIII.; and the following Table shows the general results :—

TABLE XXX.

RESULT of Experiments at Hetton and Tyne Main Collieries on the Consumption of Coal.

TIME.	Description of Experiments.	TEMPERATURE. At Bank.	In Return Air.	Bottom of Down-cast.	Upcast Fathoms, 10.	Upcast Fathoms, 65.	—	Cubic Feet of Air passing down the Downcast Shafts per Minute.	Water Gauge.	Consumption of Coals. Lbs. per Minute.	Consumption of Coals. Cubic Feet of Air for each Lb. of Coal.
1852:									Inch.		
Nov. - 26 & 27	3 furnaces - -	44°	68°	45°	- -	130°	Hetton Colliery -	208,466	1·20	18·86	11·066
1853:											
January - 3	37 jets, ¼ inch diameter each.	45	68	46	86°	90		159,913	·80	25·28	6·400
,, - 8	1 furnace, 9 feet -	44	68	45	94	98 ·5		164,750	1·00	10·11	16·320
,, - 20	2 furnaces - -	49·75	63	51	161·75	145 ·5	Tyne Main Colliery	101,876	·925	16·76	6·080
,, - 28	61 jets, ⅞ inch diameter.	35 5	62 5	40	30 fms. 63 ·75			47,467	·38	21·32	2·223

The result of the experiments at Hetton is, that with one furnace, and when the furnace ventilation of the colliery was reduced so as to be as nearly as possible equal to that of the jets, the consumption of coals with the furnace was 10·11 lbs. per minute; the consumption with the jets 25·28 lbs.; the quantity of air produced by each lb. of coal being, with the furnace 16,320 cubic feet per minute, and with the jets only 6,400 cubic feet per minute. So far, therefore, as regards their comparative economy, when the powers are nearly alike, the economy is in favour of the furnace as 2·55 : 1, when the jets are placed at the bottom of the pit, and having the aid of the heat from the boiler fires and the steam, as assistant ventilating powers.

As a substitute for the furnace, the steam jets are, therefore, decidedly deficient, when the powers are equal, and when the only motive for substitution is economy; and this, it will be seen, holds good, or is increased in favour of the furnace, when working at a higher water gauge, and within the limits in which substitution is practicable, and this we shall now consider.

Appendix, No. 1.

The experiment on the 26th and 27th November, Table XXX., shows the furnace power of the every-day working of the Hetton Colliery, three furnaces *B B* and *C*, Figs. 4 and 5, Plate I., unaided by the engine fires *E*; the amount of this ventilation is 208·466 cubic feet per minute; supposing the steam jet ventilation increased by additional boilers and jets to this extent, and that the consumption of coals is not comparatively greater. Comparing, then, the experiments with the single, and with three furnaces, we find the increase of the consumption of coal for each cubic foot of air as 16,320 : 11,066, the increase by the jets will be, from the preceding investigations, in a greater ratio; suppose, however, it is the same, then we have as 16,320 : 11,066 :: 6,400 : 4,340 cubic feet of air for each lb. of coal by the jets. When the jet ventilation is, therefore, carried to the standard of the three furnaces, the quantity of air for each lb. of coal by the furnaces being 11,066, the relative consumption of coals, by the substitution of steam jet for the furnace ventilation at Hetton Colliery, will be as 11,066 : 4,340, or nearly three times the quantity with the steam jets as with the furnace, at the every-day working of the furnace power of Hetton Colliery.

At Tyne Main Colliery the result is nearly the same, as will be seen by Table XXX., the relative quantity of air per each lb. of coal being as 6·080 : 2·223, and this is the result, the water gauge of the jets being ·38, and the furnace ·925 inches.

It will be seen from the experiments at Hetton (Table XXX.) that the impulsive force of the jets is about the same as that which resulted from the previous experiments. The quantity of air by the single furnace was 164·750 cubic feet per minute, with a mean temperature of 98°5 = 1,672 cubic feet of air per minute for each degree of heat; the mean temperature of the heat from the engine fires and steam was 90°; therefore 90° × 1,672 = 150·480, deducted from 159·913, leaves 8·573 cubic feet per minute due to the impulsive force of the jets, the mean of 12 hours' experiment, with a water gauge of 4·8 lbs. per square foot, the jets at the bottom of the pit.

And at Tyne 47,407 cubic feet per minute (Table XXX.) less 35·914 (the natural ventilation as per Table XXVIII.) = 11,493 cubic feet per minute, with a water gauge of 2·28 lbs. per square foot, the jets being at the top of the pit.

The practical conclusions, resulting from these experiments, may be tabulated as follows :—

STEAM JETS AS A SUBSTITUTION OF THE FURNACE.

Hetton Colliery—Jets at Bottom of Pit.

	Due to Temperature of Upcast Shaft.	Impulsive Force of Jets.	Total.	Consumption of Coal.
	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Lbs. per Minute.
Furnace - - -	208·466	- - -	208·466	18·86
	164·750	- - -	164·750	10·11
Jets - - - -	151·340	8,573	159·913	25·28

Tyne Main Colliery—Jets at Top of Pit.

	Due to Temperature of Upcast Shaft.	Impulsive Power of Jets.	Total.	Consumption of Coal.
	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Lbs. per Minute.
Furnace - - -	101·876	- - -	101·876	16·76
Jets - - - -	35·914	11·493	47·407	21·32

STEAM JETS AS AN AUXILIARY TO THE FURNACE.

HETTON COLLIERY.—JETS AT BOTTOM OF PIT.

	Due to Temperature of Upcast Shaft.	Impulsive Power of Jets.	TOTAL.	Consumption of Coal.
	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Cubic Feet of Air per Minute.	Lbs. per Minute.
Furnace - - -	208·466	- - -	208·466	18·86
Jets - - - -	208·466	4,917	213·383	47·97

In these investigations, I have not taken into account the quantity of air required to work the engine fires, when the jets are placed at the bottom of the pit, a quantity more than the impulsive power of the jets, as it may be said this air might be obtained from the return air after passing through the workings. I have great doubts that this can be beneficially accomplished, but as I could not ascertain this by experiment, I have not made any allowance for the increased loss of power in the jets by such air passing up the shaft, which I ought otherwise to have done.

In conclusion, the practical result of all these experiments is, that within the limits or range of furnace ventilation, the steam jet acting as a *substitute* is attended with an increase in the expenditure of fuel of nearly 3 : 1, without any corresponding advantage either in the steadiness, security, or efficiency of ventilation; on the contrary, from its simplicity of construction, the steadiness of its action, its less liability to derangement, its economy, and its efficiency in cases of emergency, the furnace is a more secure, more safe and more eligible mode of ventilation than the steam jet.

And, with respect to the steam jet as an *auxiliary* to the furnace, the conclusion is that the increase of effect of the jets over the furnace is quite inconsiderable; that such increase is extremely unsteady, in some cases nothing at all, when the furnace is urged to its maximum effect; and, in the ordinary working state of the furnace (supposing the furnace kept within its limit, so as to have adequate spare power in cases of emergency), amounting to only about 2 or 2½ per cent. That such increase is, however, attended with a loss of power, or increase in the consumption of coal, as compared with the furnace, of nearly 3 : 1. And, taking into account the uncertainty of its action, and that the increase of 2 to 2½ per cent. is only obtained when the furnace is about 10 per cent. within its maximum power (*see* Experiment, Plate VII., and Experiment, Table V.), and seeing, likewise, that when the furnace is urged to its maximum power, in cases of emergency, an increase of 10 per cent. can be immediately obtained by the furnace (*see* Experiment, pp. 148, 149), it is quite clear that the steam jet is equally ineligible and inefficient as an *auxiliary*, as when applied as a *substitute* for the furnace in the ventilation of coal mines.

And, setting aside all considerations of loss of power or of economy, and looking only to the two ventilating powers, with reference to their comparative efficiency of producing increased ventilation, and so adding to the security and safety of the mine (for I agree with the Committee of the Commons of 1852, "That a generally increased ventilation is the truest security against explosions"), it is quite clear that it would neither be advisable nor safe to depend upon any increased quantity of air as a security from explosions which might be obtained by the steam jet above that which can be obtained from the furnace, and that the only safe and secure dependence, so far as regards vigorous ventilation, as a security against explosions, is upon a well-constructed furnace or furnaces, proper adaptation and arrangement of shaft power, capacious air passages, and upon a well-regulated distribution of the air currents, and not upon the complicated and uncertain action of the steam jet.

And, lastly, I must beg permission to point out the deep obligations which the Institute and mining interests generally are under to the Hetton, the Marley Hill, and the Tyne Main Coal Companies, for their liberality in placing their pits at my disposal, and for the expense and inconvenience which they have been put to in the prosecution of these experiments; and I have also to express the obligations I am personally under to them, and to Messrs. Johnson, Greenwell, Liddell, and Wales, the viewers at these collieries, and to the other gentlemen from whom I have received aid and assistance in this arduous undertaking.

Nicholas Wood.

Appendix, No. 1.

APPENDIX, No. 1.

SYNOPSIS of the VENTILATION of HETTON COLLIERY, with the respective Distances which each Current of Air travels, and the Quantity of Air in each Split. —October 28th, 1853.

MAIN CURRENTS.

MINOR EAST DOWNCAST PIT; HUTTON SEAM.

	Cubic Feet per Minute.	Area of Air Courses.
1. Through the West Stables - - - - -	2,000	36
2. First West Incline - - - - - -	11,500	40
3. Stone Drift Incline - - - - - -	6,200	49
4. Middle North Way - - - - - -	5,800	49
5. North-east X Cut - - - - - -	7,150	50
6. First East Way, Engine Plane - - - -	6,500	50
7. South-east X Cut - - - - - -	6,200	50
1. From the Eppleton West Drifts, through Lyons Waste	—	—
2. From - - - ditto - - - - - ditto - -	—	—
TOTAL - - -	45,350	

MINOR WEST DOWNCAST PIT; HUTTON SEAM.

	Cubic Feet per Minute.	Area of Air Courses.
1. Middle South Way - - - - - -	7,500	30
2. Low South Way - - - - - - -	8,300	30
3. South X Cut Way - - - - - -	7,600	40
4. East Engine Plane - - - - - -	8,400	40
5. Third North Way - - - - - - -	7,700	30
6. Through Elemore Isabella Pit, North Way, and through the Minor Pit Waste - - - -	10,300	40
TOTAL - - -	49,800	

EPPLETON JANE DOWNCAST PIT; HUTTON SEAM.

	Cubic Feet per Minute.	Area of Air Courses.
1. High West Drift Way - - - - -	5,600	49
2. Fourth North-west Drift Way - - - -	6,000	30
3. North beyond the Engine (west) - - - -	3,200	25
4. Ditto - - - ditto - (east) - - - -	3,500	25
5. Second South Way, down the Engine Plane - -	5,500	42
6. Second North Way - - ditto - - - -	5,400	36
7. Third South Way - - ditto - - - -	5,100	36
8. Fourth North Way - - ditto - - - -	5,400	40
9. Fourth South Way - - ditto - - - -	5,000	40
10. Fifth North Way - - ditto - - - -	5,700	40
11. East Drift Way - - - ditto - - - -	5,300	40
TOTAL - - -	55,700	

APPENDIX, No. 1—*continued.* Appendix, No. 1.

MINOR EAST DOWNCAST PIT; LOW MAIN SEAM.

	Cubic Feet per Minute.	Area of Air Courses.
1. First North-east Way	7,500	36
2. Second North-east Way	6,400	36
3. South-east Way	5,100	25
4. First West Way, south side	5,000	25
5. First West Way, north side	5,200	25
TOTAL	29,200	

MINOR WEST DOWNCAST PIT; MAIN COAL SEAM.

	Cubic Feet per Minute.	Area of Air Courses.
1. South District	7,000	50
2. West District	5,500	30
3. North District	7,450	50
4. From the Eppleton Shaft, west; and north to Blossom Shaft	10,000	30
TOTAL	29,950	

TOTAL MAIN CURRENTS.

	Cubic Feet per Minute.
East Minor Pit	45,350
West Minor Pit	49,800
Eppleton Pit	55,700
Low Main Seam	29,200
Main Coal Seam	29,950
TOTAL	210,000

The area of the air courses, as above given, are those of the splits, or the "ingoing" and "outcoming" single currents; when the split, or single currents are united, the area of the air courses are proportionably increased.

APPENDIX, No. 1—*continued.*

STATEMENT of the DISTANCES travelled by the various CURRENTS of AIR in the Minor East Pit, Hutton Seam, at Hetton Colliery, through the Workings and Returns to the Blossom Pit Upcast, 28 October 1852.

	"In-going," or "Fresh Air Currents."								*See* Account of Eppleton.	
SPLITS - -	- -	1.	2.	3.	4.	5.	6.	7.	1′.	2′.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1, 2, 3, 4, 5, 6 and 7	88	88	88	88	88	88	88	88	—	—
1 - - - - -	44	44	—	—	—	—	—	—	—	—
2, 3, 4, 5, 6 and 7 -	407	- -	407	407	407	407	407	407	—	—
2 - - - - -	594	- -	594	—	—	—	—	—	—	—
3, 4, 5, 6 and 7 -	152	- -	- -	132	132	132	132	132	—	—
3 and 4 - - - -	440	- -	- -	440	440	—	—	—	—	—
3 - - - - -	880	- -	- -	880	—	—	—	—	—	—
4 - - - - -	880	- -	- -	- -	880	—	—	—	—	—
5, 6 and 7 - - -	638	- -	- -	- -	- -	638	638	638	—	—
5 - - - - -	110	- -	- -	- -	- -	110	—	—	—	—
6 and 7 - - - -	462	- -	- -	- -	- -	- -	462	462	—	—
6 - - - - -	286	- -	- -	- -	- -	- -	286	—	—	—
7 - - - - -	462	- -	- -	- -	- -	- -	- -	462	—	—
		132	1,089	1,947	1,947	1,375	2,013	2,189	—	—

	"Out-coming," or "Return Air Currents."									
SPLITS - -	- -	1.	2.	3.	4.	5.	6.	7.	1′.	2′.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1 - - - - -	44	44	—	—	—	—	—	—	—	—
1, 2, 3, 4, 5, 6, 7, and 1′ and 2′ - -	143	143	143	143	143	143	143	143	143	143
2 - - - - -	1,078	- -	1,078	—	—	—	—	—	—	—
3 - - - - -	1,144	- -	- -	1,144	—	—	—	—	—	—
4 - - - - -	1,452	- -	- -	- -	1,452	—	—	—	—	—
3 and 4 - - -	352	- -	- -	352	352	—	—	—	—	—
3, 4, 5, 6, 7, and 1′ and 2′ - -	913	- -	- -	913	913	913	913	913	913	913
5 - - - - -	484	- -	- -	- -	- -	484	—	—	—	—
6 - - - - -	1,100	- -	- -	- -	- -	- -	1,100	—	—	—
7 - - - - -	957	- -	- -	- -	- -	- -	- -	957	—	—
6 and 7 - - -	704	- -	- -	- -	- -	- -	704	704	—	—
1′ and 2′ - -	880	- -	- -	- -	- -	- -	- -	- -	880	880
		187	1,221	2,552	2,860	1,540	2,860	2,717	1,936*	1,936*
Brought down - -		132	1,089	1,947	1,947	1,375	2,013	2,189	2,684	2,508
TOTAL Distances - -		319	2,310	4,499	4,807	2,915	4,873	4,906	4,620	4,444

* *See* Eppleton Account.

APPENDIX, No. 1—*continued.*

STATEMENT of the DISTANCES travelled by the various CURRENTS of AIR in the Minor West Pit, Hutton Seam, at Hetton Colliery, through the Workings and Returns to the Blossom Pit Upcast, 28 October 1852.

	"In-going," or "Fresh Air Currents."						
SPLITS		1.	2.	3.	4.	5.	6.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1, 2, 3, 4 and 5	737	737	737	737	737	737	
1 and 2	462	462	462	—	—	—	
1	671	671	—	—	—	—	
2	792	- -	792	—	—	—	
3, 4 and 5	308	- -	- -	308	308	308	From Elemore.
3	330	- -	- -	330	—	—	
4 and 5	737	- -	- -	- -	737	737	
4	286	- -	- -	- -	286	—	
5	341	- -	- -	- -	- -	341	
		1,870	1,991	1,375	2,068	2,123	2,816

	"Out-coming," or "Return Air Currents."						
SPLITS		1.	2.	3.	4.	5.	6.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1	1,199	1,199	—	—	—	—	
2	1,276	- -	1,276	—	—	—	
3	638	- -	- -	638	—	—	
4	286	- -	- -	- -	286	—	From Elemore through Minor Waste.
5	330	- -	- -	- -	- -	330	
4 and 5	968	- -	- -	- -	968	968	
1, 2, 3, 4 and 5	1,562	1,562	1,562	1,562	1,562	1,562	
		2,761	2,838	2,200	2,816	2,860	4,664
Brought down		1,870	1,991	1,375	2,068	2,123	2,816
TOTAL Distances		4,631	4,829	3,575	4,884	4,983	7,480

APPENDIX, No. 1—*continued.*

STATEMENT of the DISTANCES travelled by the various CURRENTS of AIR in the Jane Pit, Hetton Seam, at Eppleton Colliery, through the Workings and Returns to the Blossom Pit Upcast at Lyons, 28 October 1852.

	"In-going," or "Fresh-Air Currents."											
SPLITS		1′.	2′.	3.	4.	5.	6.	7.	8.	9.	10.	11.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1′, 2′, 3, 4, 5, 6, 8, 9, 10 and 11	110	110	110	110	110	110	110	110	110	110	110	110
1′ and 2′	1,122	1,122	1,122	—	—	—	—	—	—	—	—	—
1′	594	594	—	—	—	—	—	—	—	—	—	—
2′	572	- -	572	—	—	—	—	—	—	—	—	—
3, 4, 5, 6, 7, 8, 9, 10 and 11	209	- -	- -	209	209	209	209	209	209	209	209	209
3 and 4	396	- -	- -	396	396	—	—	—	—	—	—	—
3	396	- -	- -	396	—	—	—	—	—	—	—	—
4	330	- -	- -	- -	330	—	—	—	—	—	—	—
5, 6, 7, 8, 9, 10 and 11	880	- -	- -	- -	- -	880	880	880	880	880	880	880
5	935	- -	- -	- -	- -	935	—	—	—	—	—	—
6, 7, 8, 9, 10 and 11	15	- -	- -	- -	- -	- -	15	15	15	15	15	15
6	1,353	- -	- -	- -	- -	- -	1,353	—	—	—	—	—
7, 8, 9, 10, 11	297	- -	- -	- -	- -	- -	- -	297	297	297	297	297
7	825	- -	- -	- -	- -	- -	- -	825	—	—	—	—
8, 9, 10 and 11	143	- -	- -	- -	- -	- -	- -	- -	143	143	143	143
8	792	- -	- -	- -	- -	- -	- -	- -	792	—	—	—
9, 10 and 11	348	- -	- -	- -	- -	- -	- -	- -	- -	348	348	348
9	1,441	- -	- -	- -	- -	- -	- -	- -	- -	1,441	—	—
10	561	- -	- -	- -	- -	- -	- -	- -	- -	- -	561	—
11	1,628	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	1,628
		1,826	1,804	1,111	1,045	2,134	2,567	2,336	2,446	3,443	2,563	3,630

	"Out-coming," or "Return Air Currents."											
SPLITS		1′.	2′.	3.	4.	5.	6.	7.	8.	9.	10.	11.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1′	748	748	—	—	—	—	—	—	—	—	—	—
2′	594	- -	594	—	—	—	—	—	—	—	—	—
1′ and 2′	110	110	110	—	—	—	—	—	—	—	—	—
3	847	- -	- -	847	—	—	—	—	—	—	—	—
3 and 4	2,178	- -	- -	2,178	2,178	—	—	—	—	—	—	—
5	1,287	- -	- -	- -	- -	1,287	—	—	—	—	—	—
6	1,496	- -	- -	- -	- -	- -	1,496	—	—	—	—	—
8	1,903	- -	- -	- -	- -	- -	- -	- -	1,903	—	—	—
10	891	- -	- -	- -	- -	- -	- -	- -	- -	- -	891	—
8 and 10	242	- -	- -	- -	- -	- -	- -	- -	242	- -	242	—
6, 8 and 10	352	- -	- -	- -	- -	- -	352	- -	352	- -	352	—
7	726	- -	- -	- -	- -	- -	- -	726	—	—	—	—
9	1,419	- -	- -	- -	- -	- -	- -	- -	- -	1,419	—	—
11	737	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	737
9 and 11	660	- -	- -	- -	- -	- -	- -	- -	- -	660	- -	660
7, 9 and 11	352	- -	- -	- -	- -	- -	- -	352	- -	352	- -	352
3, 4, 5, 6, 7, 8, 9, 10 and 11	3,509	- -	- -	3,509	3,509	3,509	3,509	3,509	3,509	3,509	3,509	3,509
		858	704	6,534	5,687	4,796	5,357	4,587	6,016	5,940	4,994	5,258
Brought down		1,826	1,804	1,111	1,045	2,134	2,567	2,336	2,446	3,443	2,563	3,630
TOTAL Distances		2,684	2,508	7,645	6,732	6,930	7,924	6,923	8,462	9,383	7,557	8,888

APPENDIX, No. 1—*continued.*

STATEMENT of the DISTANCES travelled by the various CURRENTS of AIR in the Minor East Pit, Low Main Seam, at Hetton Colliery, through the Workings and Returns to the Blossom Pit Upcast.

	"In-going," or "Fresh Air Currents."				
SPLITS		1.	2.	3.	4.	5.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1, 2 and 3	120	120	120	120	—	—
1	940	940	—	—	—	—
2 and 3	290	-	290	290	—	—
2	230	-	230	—	—	—
3	200	-	-	200	—	—
4 and 5	725	-	-	-	725	725
4	200	-	-	-	200	—
5	315	-	-	-	-	315
See below for Totals		1,060	640	610	925	1,040

	"Out-coming," or "Return Air Currents."				
SPLITS		1.	2.	3.	4.	5.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1	220	220	—	—	—	—
2	220	-	220	—	—	—
1 and 2	185	185	185	—	—	—
3	670	-	-	670	—	—
1, 2 and 3	100	100	100	100	—	—
4	460	-	-	-	460	—
5	360	-	-	-	-	360
4 and 5	1,595	-	-	-	1,595	1,595
		505	505	770	2,055	1,955
Brought down		1,060	640	610	925	1,040
TOTAL Distances		1,565	1,145	1,380	2,980	2,995

STATEMENT of the DISTANCES travelled by the various CURRENTS of AIR in the Main Coal Seam at Hetton Colliery, through the Workings and Returns to the Blossom Pit Upcast Shaft.

	"In-going," or "Fresh Air Currents."				
SPLITS		1.	2.	3.	4.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1	1,165	1,165	—	—	—
2	560	-	560	—	—
3	1,080	-	-	1,080	—
4	2,360	-	-	-	2,360
See below for Totals		1,165	560	1,080	2,360

	"Out-coming," or "Return Air Currents."				
SPLITS		1.	2.	3.	4.
	Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*
1	7,010	7,010	—	—	—
2	1,220	-	1,220	—	—
3	1,620	-	-	1,620	—
4	6,460	-	-	-	6,460
		7,010	1,220	1,620	6,460
Brought down		1,165	560	1,080	2,360
TOTAL Distances		8,175	1,780	2,700	8,820

SUMMARY of VENTILATION of HETTON COLLIERY.

Minor East Downcast Pit; Hutton Seam.

	Distances.	Cubic Feet of Air per Minute.	Area of Air Courses.	Velocity in Feet per Second.
	M. F. Yards.			
1. Through West Stables	0 1 99	2,000	36	0·92
2. First West Incline	1 2 110	11,500	40	4·79
3. Stone-drift Incline	2 4 99	6,200	49	2·08
4. Middle North Way	2 5 187	5,800	49	1·97
5. North-East X Cut	1 5 55	7,150	50	2·38
6. First East Way, Engine Plane	2 6 33	6,500	50	2·16
7. South-east X Cut	2 6 66	6,200	50	2·06
1′. From Eppleton West Drifts, through Lyons Waste	2 5 0	—	—	—
2′. Ditto ditto	2 4 44	—	—	—
	19 1 33	45,350	324	2·34 Average.
			Average, 46·28	

Minor West Downcast Pit; Hutton Seam.

	Distances.	Cubic Feet of Air per Minute.	Area of Air Courses.	Velocity in Feet per Second.
	M. F. Yards.			
1. Middle South Way	2 5 11	7,500	30	4·16
2. Low South Way	2 5 209	8,300	30	4·61
3. South X Cut Way	2 0 55	7,600	40	3·16
4. East Engine Plane	2 6 44	8,400	40	3·50
5. Third North Way	2 6 143	7,700	30	4·27
6. Through Elemore Isabella Pit, &c.	4 2 0	10,300	40	4·29
	17 1 22	49,800	210	4·00 Average.
			Average, 35	

Eppleton Jane Downcast Pit; Hutton Seam.

	Distances.	Cubic Feet of Air per Minute.	Area of Air Courses.	Velocity in Feet per Second.
	M. F. Yards.			
1′. High West Drift Way	1 4 44	5,600	49	1·90
2′. Fourth North-west Drift Way	1 3 88	6,000	30	3·33
3. North, beyond the Engine (West)	4 2 174	3,200	25	2·12
4. Ditto ditto (East)	3 6 132	3,500	25	2·32
5. Second South Way, down the Engine Plane	3 7 110	5,500	42	2·18
6. Second North Way ditto	4 4 4	5,400	36	2·50
7. Third South Way ditto	3 7 103	5,100	36	2·36
8. Fourth North Way ditto	4 6 102	5,400	40	2·58
9. Fourth South Way ditto	5 2 143	5,000	40	2·08
10. Fifth North Way ditto	4 2 77	5,700	40	2·37
11. East Drift Way ditto	5 0 88	5,300	40	2·21
	42 7 185	55,700	403	2·23 Average.
			Average, 36·63	

MINOR EAST DOWNCAST PIT; LOW MAIN SEAM.

	Distances.			Cubic Feet of Air per Minute.	Area of Air Courses.	Velocity in Feet per Second.
	M.	F.	Yards.			
1. First North-east Way	0	7	25	7,500	36	3·47
2. Second - ditto	0	5	45	6,400	36	2·06
3. South-east Way	0	6	60	5,100	25	3·46
4. First West Way, South Side	1	5	120	5,000	25	3·25
5. Ditto - - - North Side	1	5	135	5,200	25	3·46
	5	5	165	29,200	147	3·32 Average.
					Average, 29·40	

MINOR WEST DOWNCAST PIT; MAIN COAL SEAM.

	Distances.			Cubic Feet of Air per Minute.	Area of Air Courses.	Velocity in Feet per Second.
	M.	F.	Yards.			
1. South District	4	5	35	7,000	50	2·33
2. West District	1	0	20	5,500	30	3·05
3. North District	1	4	60	7,450	50	2·48
4. From the Eppleton Shaft, West; and North, to Blossom Shaft	5	0	20	10,000	30	5·55
	12	1	135	29,950	160	3·35 Average.
					Average, 40	

RECAPITULATION.

	Cubic Feet of Air per Minute.	Distances.			Areas.		Velocity.
					Average.	TOTAL.	Average.
		M.	F.	Yards.			
EAST MINOR PIT	45,350	19	1	33	46·28	324	2·34
WEST MINOR PIT	49,800	17	1	22	35·00	210	4·00
EPPLETON PIT	55,700	42	7	185	36·63	403	2·33
LOW MAIN SEAM	29,200	5	5	165	29·40	147	3·32
MAIN COAL SEAM	29,950	12	1	35	40 00	160	3·35
TOTAL	210,000	97	1	100	37·46	1,244	3·11

Appendix, No. 1.

TABLE (A).

TABLE OF NATURAL VENTILATION.

COLLIERY.	Depth of Shaft, in Feet.	TEMPERATURES.						Quantity of Air, in Cubic Feet, per Minute.	Water Gauge, in Inches.
		Downcast Shaft.			Upcast Shaft.				
		Bank.	Bottom of Downcast Shaft.	Mean.	Return Air.	60 Feet from Top of Upcast Shaft.	Mean.		
		°	°	°	°	°	°		
Tyne Main -	672	36	42	39	63	62	62·5	34,955	·2
„	„	43	45	44	63	64	63·5	36,564	·2
„	„	43	45	44	63	65	64	37,182	·2
Hetton -	900	45	47	46	64	83	83	130,890	·4
„	„	39	47	43	67·3	80	80	123,463	·5
„	„	41·25	47	44	68·5	75	75	127,145	·55
„	„	54	- -	54	68	73	73	117,908	·4

TABLE (B).

TEMPERATURE OF RETURN AIR.

NAME OF COLLIERY.	Depth of Pit, in Feet.	Quantity of Air in Cubic Feet, per Minute.	Distance Air travels, in Feet.	Temperature in Return, 100 Feet from Furnace.	Temperature at Bottom of Downcast Shaft.
				°	°
Seaton Delaval - - - -	636	83,320	14,912	61	48
Haswell - - - - -	936	100,917	76,512	64	56
Hetton - - - - -	810	190,000	87,934	68	46
Willington - - - -	840	66,500	14,234	64	47
Felling - - - - -	696	63,000	5,016	66	53
Wearmouth - - - -	1,800	70,500	24,160	75	52
Thornley { Hutton Seam - -	868	26,574	59,228	65	41
Thornley { 5/4 Seam - - -	556	45,756	59,228	69	42
Wallsend A Pit - - - -	- -	- -	- -	69	46
„ B Pit - - - -	900	120,360	31,521	69	49
„ C Pit - - - -	- -	- -	- -	70	49
Walker - - - - -	960	44,800	13,780	72	49·5
Castle Eden - - - -	1,038	42,326	66,102	64	62
South Hetton - - - -	1,212	132,895	37,272	71	52

TABLE (C.)

CONSUMPTION OF COAL BY FURNACES.

COLLIERY.	Coals in 24 Hours.	Cubic Feet of Air per Minute.	Mean Temperature Midway.	Temperature 100 Feet from Furnace.
	Cwts. qrs. lbs.		°	°
Seghill	60 0 0	42,708	122	62
Willington	70 0 0	66,500	138	64
Felling	72 0 0	63,000	128	66
Thornley, Hutton Seam	48 0 0	26,574	79	65
„ 5/4 „	48 0 0	45,756	94	69
Wingate Grange	56 0 0	45,000	120	69
Wallsend A Pit	28 2 0	27,000	135	69
„ B Pit	28 2 0	45,100	130	69
„ F Pit	32 0 0	48,260	110	70
Walker	29 3 0	44,800	98	72
Castle Eden	45 0 0	42,326	103	63
Wearmouth	30 0 0	70,500	84	75
South Hetton	110 0 0	132,895	90	72
Percy Main, H. Main	24 0 0	18,805	94	65
„ Bensham	45 0 0	35,893	116	66
West Auckland	18 0 0	14,478	120	54
Mickley	18 0 0	15,000	77	56
	762 3 0	784,595	1,838	1,126
Average per Minute with 1 lb. of Coal	- - -	13,076	108	66

PAPER (D.)

EXPERIMENTS made at St. Hilda Colliery, in resuming the Ventilation of that Colliery, after having been suspended to put in Tubbing, the Workings being entirely filled with Fire-damp.

No. 1.—With Jets alone, placed at Top of Pit. 20 May 1853.

Harton Pit to Bensham Seam (downcast)		210 fathoms.
„ surface above Hilda	8 fathoms.	
Hilda Pit shaft (upcast)	139 „	
		147 „
Hilda Pit bottom, above Harton		63 „

There are two boilers employed, each 30 feet × 7 feet.
16 steam jets, ¼-inch diameter, = ·78 feet area.
Cylinders on jets, 11 inches diameter, = 10·5 feet area, 6 feet long.
Pressure on boilers, 30 lbs. on the square inch.
Diameter of steam-pipe, 6 ¾ inches.
Diameter of jet-pipes, 3 inches.
Water evaporated = ·88 cubic feet per minute.
Coals burnt, 9·8 lbs. per minute.
11·0 lbs. of coal per cubic foot of water.
Distance from centre of boiler to centre of jets, 66 feet.
Area of Hilda upcast, 98 feet, top part.
„ „ 82 „ lower part.
„ Harton downcast, 58 square feet.

Appendix, No. 1.

Temperature at surface, Harton Pit		54°
„ at bottom of downcast	58	
„ midway between the Hilda and Harton Pits	72	
„ Hilda return air at furnace doors		72
Increase for natural ventilation		18

Barometer at surface	30·20
„ at bottom of Harton	31·56
Difference	1·36

Air measured in barrier-holing between Hilda and Harton Pits, with 16 ¼-inch jets at work; steam, 30 lbs. Total, 10,500 cubic feet per minute.

Also measured the quantity with jets off.

6,750 cubic feet per minute.

No. 2.—Steam Jets at work (20 of them), and without the Cylinders on; the Pressure of the Steam, &c. &c., the same as in No. 1; and one Engine Fire at work under-ground, in addition. 23 June 1853.

Temperature, Harton Pit, bank, shade	56°
„ bottom of pit, downcast	60
„ midway between Hilda and Harton Pit, in Bensham Seam	72
„ Hilda return air at furnace doors	72
„ furnace drift at bottom of Hilda Pit	80

Barometer, surface, Harton Pit	30·03
„ bottom of ditto	31·45

Size of boiler fire, 5 ft. × 4 ft. (fire-door kept open; air sent over fire; size of this door, 28 in. × 14 in.)

Dimensions of boiler, 18 ft. × 6 ft.; quantity of water evaporated, 3 ¼ in. in 4 hours; and coals consumed, 6 ¾ cwt. in 4 hours, 3·15 lbs. per minute.

Dimensions of flue, 9 in × 18 in.; the distance of the fire from the bottom of pit, 528 yards.

Quantity of air in barrier-holing between Harton and Hilda Pits, 14,658 cubic feet per minute.

This quantity obtained by the engine fire and the steam jets; but 3,600 goes to work engine fire, leaving 11,058 cubic feet going into the workings.

No. 3.—Experiment with Jets on same, as in No. 2 Experiment, with Engine Fire put out and Furnace lighted; 20 Jets. 5 July 1853.

The furnace having been lighted three days;

The engine fire put out on lighting the furnace.

The furnace fed by a scale of fresh air, the return air going up staple into dumb drift, and so into shaft.

Temperature, Harton Pit bank, shade	64°
„ bottom of pit, downcast	64
„ midway between Hilda and Harton Pits, in Bensham Seam	72
„ Hilda return at furnace doors	72
„ „ shaft, 10 fathoms down	74
„ „ „ midway down	78
„ „ furnace drift, 120 fathoms down	96 (in shaft).

Barometer, surface, Harton	30·06
„ bottom, „	31·37

The quantity of coals burnt at furnace in 12 hours, 12 cwt.; 2 lbs. per minute.
Total air passing through barrier-holing, 17,611 cubic feet per minute.
Furnace is 220 yards from shaft, and is an 8 ft. in width furnace; bars 11 ft. in length.

PAPER (E.).

Killingworth, 6 June 1853.

EXPERIMENTS with Safety Lamps, to test at what Velocity in an explosive Mixture of Fire-Damp and Atmospheric Air the Flame may be passed through the Wire Gauze.

The experiments were made in a box (shown in Fig. 1, Plate G, Appendix), 2 ft. 2 in. long, 2 ft. 9 in. broad, and 1 ft. 4 in. deep, having plate-glass windows in one side for observation, and the box was fitted with a spindle with arms, to which were attached rings with screws for fixing the lamps at the end of the arms. On the under side of the box was placed a handle for turning the axle, so as to enable the number of revolutions to be ascertained. The gas, after being mixed with air in a gasometer (shown in Fig. 2, Plate G), was by water pressure forced into the box, and the lamps, after attaining a red heat, set in motion. Diameter of circle the lamps made was 28 ins. = 88 in circumference.

No. of Lamp.	Name of Lamp.	Number of Revolutions after Red Heat.	Time, in Seconds.	Velocity, in Feet, per Second.	Result.
1	Davy - - -	160	116 ½	10	Did not pass flame.
	Ditto - - -	200	114	11	- ditto.
		Number of Revolutions after White Heat.			
2	Davy - - -	60	29	15	Passed flame.
	Ditto - - -	26	10	19	- ditto.
3	Jack lamp - -	In this experiment the velocity not taken.			- ditto.
4	Stephenson, without a glass - - -	28	142	14	- ditto.
5	Clanny, with copper gauze - - -	12	7	122	- ditto.
6	Clanny, with iron wire gauze - - -	96	44	16	Did not pass.
	Ditto - - -	20	10	15	- ditto.

Killingworth Colliery, 29 June 1853.

Resumed Experiments.

1. *Davy Lamp.*—1st Experiment. In this experiment the lamp, after arriving at a dull red heat, was put in motion at a velocity of 15 ft. a second without passing the flame, having made 248 revolutions in 121 seconds, the temperature in the box during the experiment varying from 69° to 94° Fahr.

2. *Davy Lamp.*—2d Experiment. The lamp, after heated to nearly a white heat, was moved at a velocity of 13 ft. a second, having made 52 revolutions in 29 seconds, and the flame passed. Temperature in box varied from 69° to 82° Fahr.

A Davy lamp was afterwards heated to a red heat, and whilst being moved at a considerable velocity very fine coal-dust was thrown upon it by means of a pair of bellows, the pipe of which was inserted in the side of the box. On this being done, a portion of the coal-dust rebounded from the lamp, whilst the dust appeared to produce bright luminous explosions within the lamp, so much so as to lead an observer to imagine that the flame had actually passed through the gauze. Oil was then poured upon the gauze, together with coal-dust blown upon it, so as to put the lamp in a condition, as nearly as might be, to that which it would be in when in the hands of a careless workman. It was then put in quick motion; a white heat was obtained, and continued for some time without the flame being passed.

3. *Clanny's Lamp* was tested in the same manner as the Davy lamp, in the first and second experiments. The flame passed on attaining a high velocity, and the glass cracked.

Clanny's Lamp.—2d Experiment. The same lamp, in its damaged state, was again tried, and moved at a velocity of 17 ft. per second (68 revolutions in 29 seconds), but without the flame being passed, the lamp having become extinguished.

Appendix, No. 1.

4. *Boty Lamp*, used in Belgium, being authorised by the Government inspectors. This lamp, after acquiring a white heat, and making 12 revolutions in six seconds, which is equal to a velocity of nearly 15 ft. per second, passed the flame and cracked the glass. Temperature in the box during the experiment varied from 70° to 88° Fahr.

5. Another lamp with a short gauze was also tried, and the flame passed, but the velocity was not ascertained.

6. *Eloin's Lamp*, with wire gauze, in substitution of the glass. In this experiment, which was conducted in a manner similar to the others, the velocity was not ascertained, but the flame passed when the lamp was moving at considerable velocity, and at a white heat.

7. *Hall's Lamp*. Tested in the same manner; did not pass the flame, the velocity in this case having been 13 ft. per second.

8. *Cail and Glover's Lamp* was also tested, and the flame did not pass, but the inner glass cracked.

Crookbank Colliery, 27 April 1850.

Experiment made with a view to ascertain the Friction of Air Currents in Mines, or the Factor by which to multiply the Theoretical Velocity, as obtained by calculation, in order to obtain the actual Velocity. By G. C. Greenwell.

Depth of downcast shaft	228 feet.
Diameter of ditto	9 „
Set of pumps, 19 inches outside of flange.	
Cage buntons, 8 feet long × 6 inches broad.	
Depth of upcast	219 „
Diameter of ditto	6 „

Length and dimensions of a single passage between the pits, the same being completely separated by stoppings along its side from the rest of the workings.

	Ft.	*in.*		*Ft.*	*in.*
At 1 chain from shaft	6	3	×	8	4
2 „ „	6	1	×	5	8
3 „ „	6	3	×	5	8
4 „ „	5	10	×	5	10
5 „ „	6	3	×	5	4
6 „ „	6	0	×	6	0
7 „ „	5	3	×	8	0
8 „ „	5	9	×	5	4
9 „ „	6	0	×	5	5
10 „ „	5	8	×	5	1
11 „ „	4	6	×	5	1
12 „ „	5	2	×	5	3
13 chains from furnace	5	0	×	5	0
and 13·77 chains to shaft	5	0	×	5	0
Average	5	7¾	×	6	3

At 10·72 chains is a door to the furnace (size of door, 3 ft. 4 in. × 3 ft. 6 in.), through which the whole of the air passed at the time of the experiment.

Dimensions of Drift where Velocity of Air was tried.

Ft.	*in.*		*Ft.*	*in.*
4	6	×	5	1
5	3	×	4	6
5	3	×	4	6
5	2	×	5	3
Average 5	0	×	4	10 = 24·366 square feet.

Time of air travelling 60 feet	5½ seconds.
Quantity of air	15,948·65 cubic ft. per min.
Temperature of upcast	175° Fahr.
„ downcast	47 „
Diff.	128 „

Length

Length of air-course from top of downcast to top of upcast - 1,353 feet.
Mean area of whole course - - - - - - - 36·31 „

Theoretical velocity = V

$$V = 8\sqrt{\frac{h\,(t'-t)}{480+t'-32}} = 53{\cdot}6656 \text{ feet per second.}$$

Where h = length of upcast.
„ t' = temperature of hot column.
„ t = „ cold „

The actual velocity $v = 7{\cdot}1885$ feet per second.

Then, since according to Peclet,

$$v = V \times 2{\cdot}06\sqrt{\frac{D}{L+4D}}$$

If we substitute the above values for v, V, L, and 6, or $\surd 36{\cdot}31$ for D, and x for 2·06, we have

$$v = V \times 2{\cdot}0295\sqrt{\frac{D}{L+4D}}$$

or, in other words, the factor resulting from the above experiment accords almost exactly with that deduced by M. Peclet.

Where the above experiment was made the coal seam is four feet in thickness, perfectly free from fire-damp, but contains a considerable quantity of carbonic acid. The surface is here (at the pit) 593·42 feet above high-water mark.

PAPER (F.)

EXPERIMENTS to test various SAFETY LAMPS, tried at WALLSEND COLLIERY, 28 June 1853.

Present: Thomas John Taylor, George Clark, Thomas Irving, Engineer of Colliery, the Master Wasteman, and others.

THE gas made use of is direct from the mine, being conveyed in a four-inch pipe, from a barred-up space of about 50 acres at the depth of 140 fathoms, and thence up the C. pit shaft. It was received, by means of a small pipe and stop-cock, into a horizontal wooden box 12 feet long, and 18 inches square inside, with windows at each end; and two windows on the top.

A double groove was made at three inches from the bottom of the box, with a sliding platform which moved in it, and on which the lamps were firmly fixed by wedge pieces.

A horizontal wheel was placed outside at each end of the box, the two wheels being connected by a cord which passed round the periphery of both, one cord being outside, and the other inside the box. The inside cord was attached to each end of the moveable platform. A check string was also attached, which allowed a movement in either direction of 11 feet, and prevented the lamps from coming in contact with the ends of the box.

An upright shaft with a handle was attached to one of the wheels, by turning which various rates of velocity might be communicated at pleasure to the moveable platform, and the lamp upon it in the interior. The indications of foulness were at once apparent from the effect on the lamp.

The box was kept cool by admitting fresh air in the intervals of, and sometimes during the experiments, the ends being moveable.

The temperature of the external air was 64°.

The temperature of the gas was 65½°.

The time was measured by a watch with a large second hand pointer, capable of determining accurately a quarter of a second.

Experiment 1. With the common Davy lamp. The lamp, immersed in an inflammable atmosphere, and filled with flame, was moved backwards and forwards, always completing the distance of 11 feet within the second. Taking into account the slightly diminished velocity at the commencement and termination of the movement, and the greater velocity in the middle of it, the lamp moved at rates of from 10 to 12 feet per second during the experiment.

This rapid movement increased the brightness of the gas combustion in the interior of the lamp, but had no other effect, until by a still greater speed the lamp was extinguished.

Appendix, No. 1.

2. Repeated the same experiment, after relighting the lamp, and preparing a new inflammable atmosphere in the box.

The results were as in experiment 1.

3. Repeated the same experiment, in a similar way, with similar results.

4. Allowed the Davy lamp to remain in the inflammable atmosphere until the gauze was red hot, and then moved it as before with a velocity of 10 to 12 feet per second. The lamp in motion presented a column of light brighter than in experiments 1, 2, and 3, and by increasing the velocity was extinguished.

5. Jerked the Davy lamp backwards and forwards in the inflammable atmosphere with great velocity, while the gauze was red hot; at each reversal of the jerk a flash took place in the interior of the lamp, but no other effect followed, until the lamp was extinguished by the violence of the motion.

In all these experiments the entire lamp was filled with gas, but the flame of the wick continued visible. There can be no question as to the clear character of the experiments.

6. *Stephenson's Lamp.*—Was extinguished at a much lower velocity than that to which the Davy admitted of being subjected.

7. *Musler's Lamp.*—With copper chimney inside, was extinguished as in No. 6.

8. *Clanney's Lamp.*—First moved backwards and forwards without passing any explosion; but was extinguished before being submitted to as high a velocity as that of the Davy.

9. *Clanney's,* Second trial.—Went out after being moved backwards and forwards several times, though kept full of flame for some time without the glass becoming so heated as might have been expected.

Velocity of movement much less than that of the Davy.

10. *Glover's Lamp.*—First went out at third movement.

11. *Glover's,* Second Trial.—Went out (less velocity than with Davy.)

12. *Eloine Lamp.*—A German lamp (Thornton & Co.) 1st. Went out on moving a few times with less velocity than Davy.

13. *Eloine,* Second Trial.—Went out as soon as it filled.

14. *Upton and Robert's Lamp.*—Went out at once in inflammable atmosphere.

PLATES.

[To face page 176]

PLATE I.

Fig. 1.

Fig. 3.

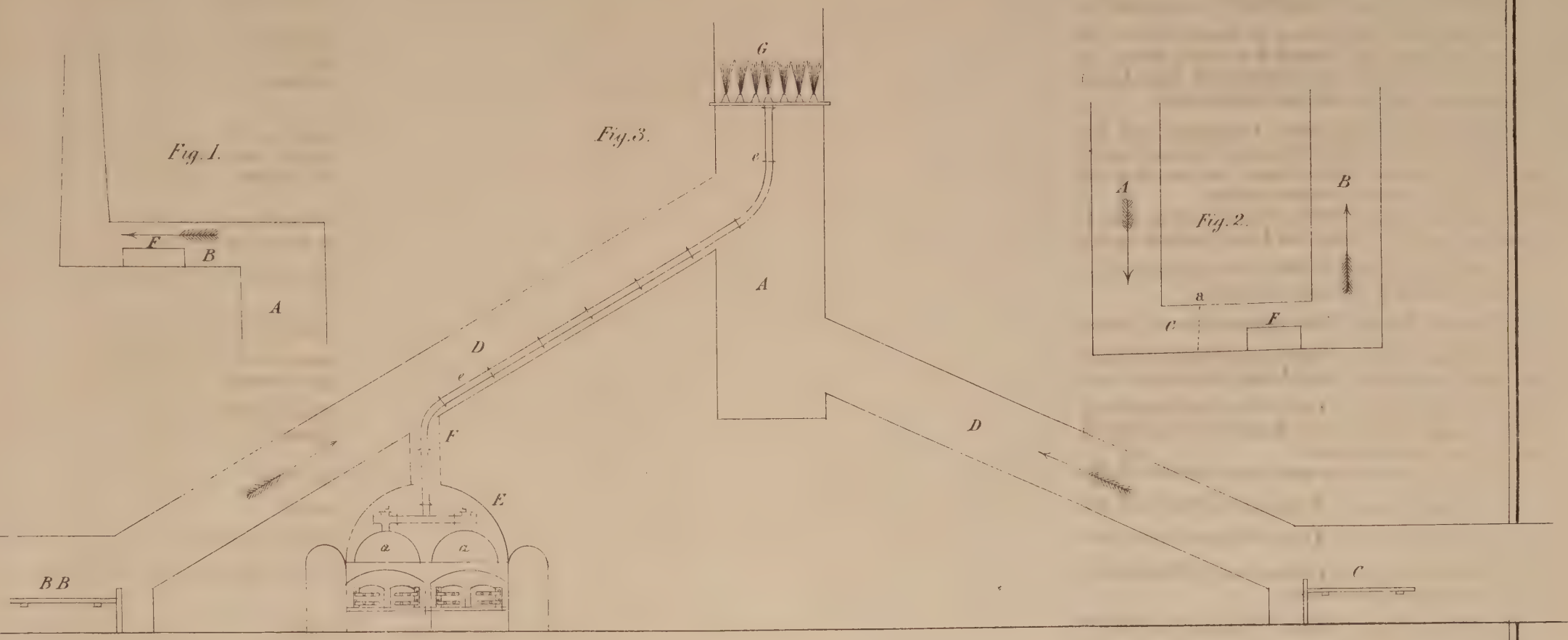
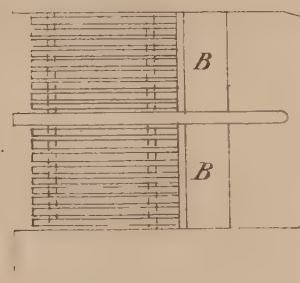


Fig. 2.

Fig. 4.



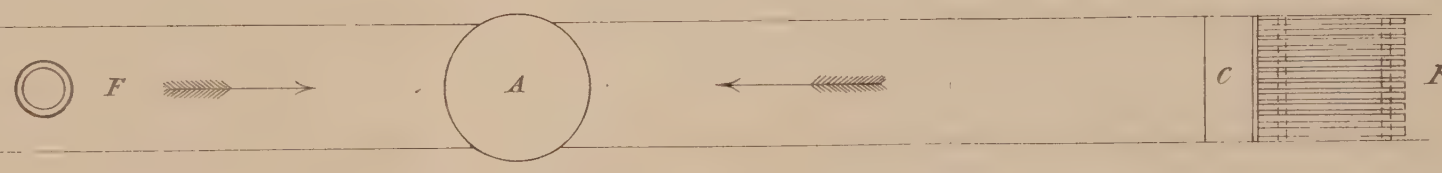


Fig. 5.

Fig. 8.

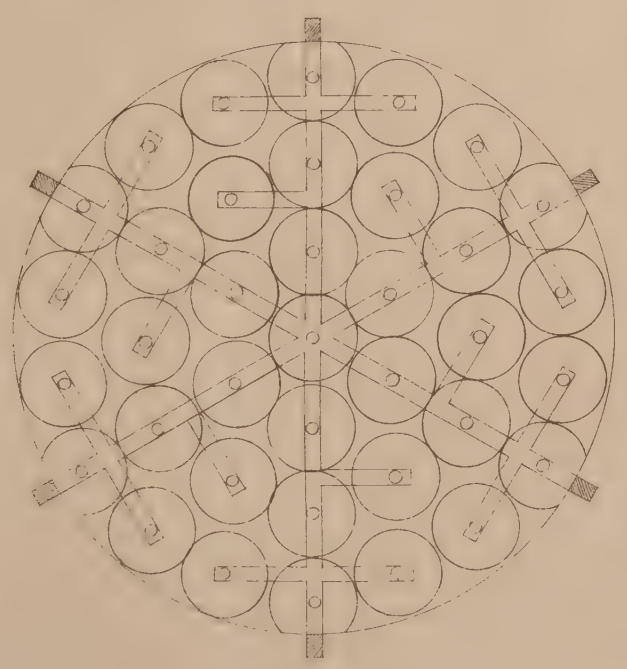
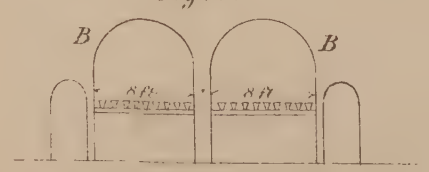


Fig. 7.

Fig. 6.



SCALE OF PLAN. .

J.Basire, Lith.

No. 820. Ordered, by The House of Commons, to be Printed, 26th July 1853.

Henry Hansard, Printer.

PLATE II.

Fig. 3.

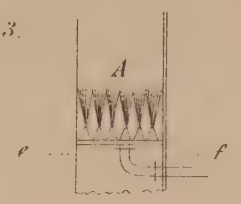
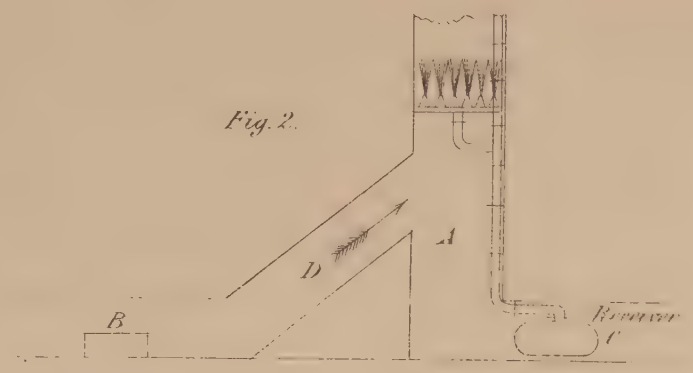


Fig. 2.



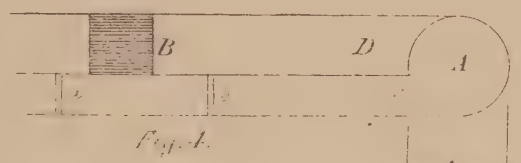


Fig. 4.

Fig. 5.

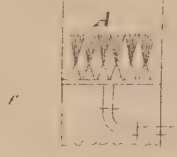


Fig. 8.

Fig. 9.

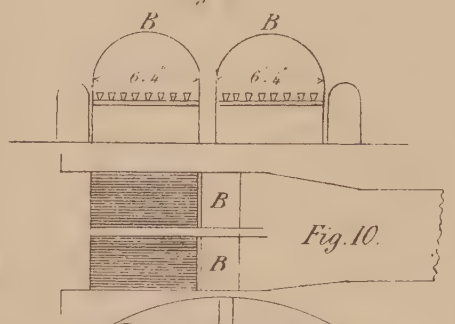


Fig. 10.

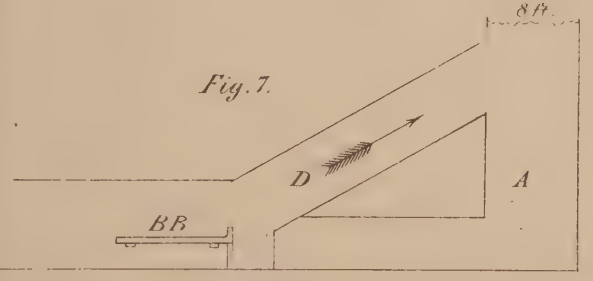


Fig. 7.

Fig. 11.

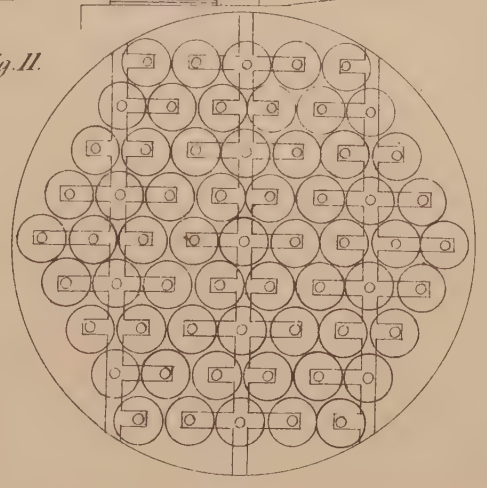


Fig. 6.

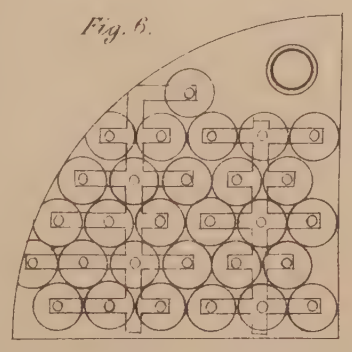
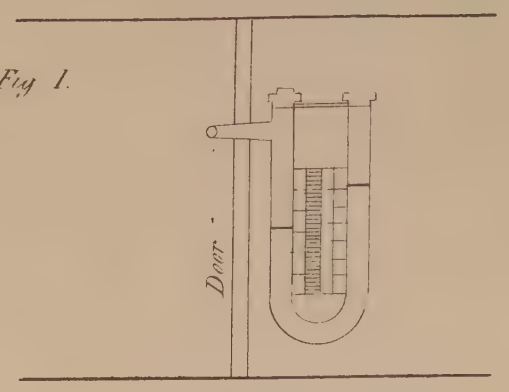


Fig. 1.



No. 1.–19,470 feet.

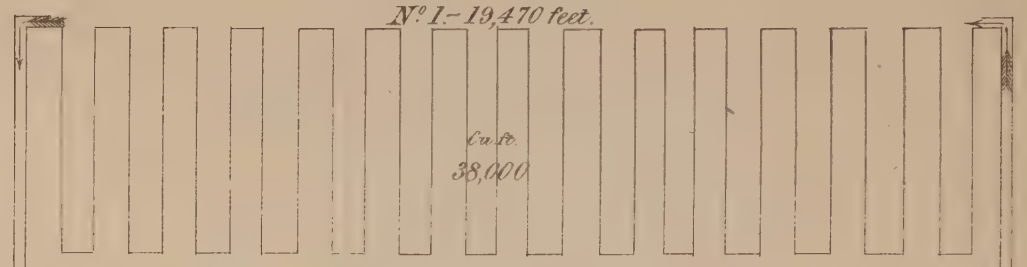


Fig. 12.

No. 2.– 6,400 feet.

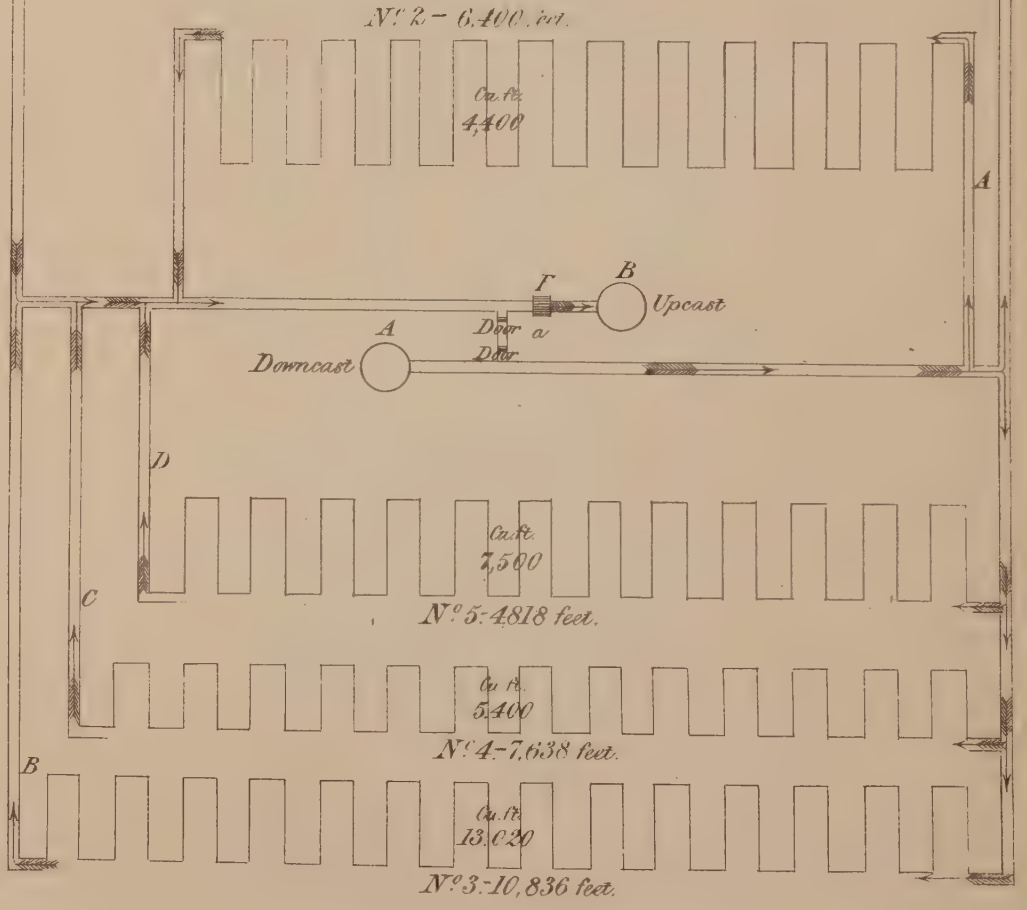


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PLATE III.

Fig. 1.

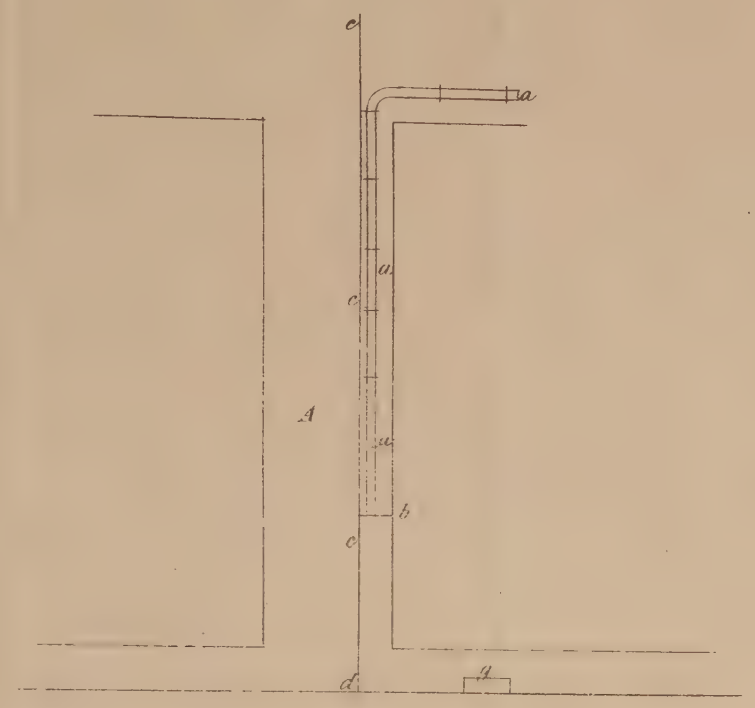


Fig. 2.

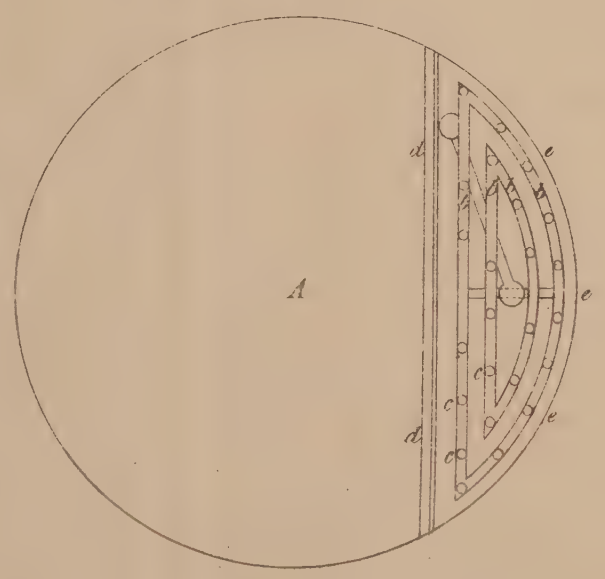
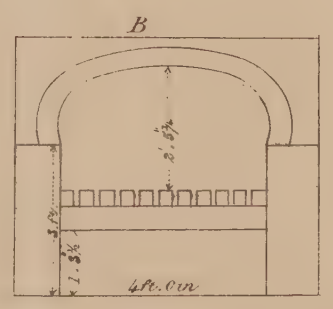


Fig. 3.



SCALE OF FEET.

1 2 3 4 5 6 7 8 9 10

PLATE IV.

HETTON COLLIERY.

Water Gauge or Drag of Air in Inches.	Velocity of Air through Workings in feet per Second.	Cubic feet of Air per Minute.	
·5	13·45.	123·463.	Natural Ventilation.
·6	14·8.	135·950.	Engine Fires.
·6	15·23.	139·847.	Engine Fires & Steam.
·8625	17·86	164·000	Steam Jet.
1·75	23·	211·193	Furnace
1·95	24·5.	225·176.	Furnace
2·0.	25·	229·918	Furnace & Engine Fires
2·05.	25·5.	234·118.	Furnace & Jets

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PLATE V.

KILLINGWORTH COLLIERY.

Water Gauge or Drag of Air in Inches.	Velocity of Air through Workings in feet per Second.	Cubic feet of Air per Minute.	
·5	5·1	9·176.	Natural Ventilation
·55	16·	28·888.	Steam
·70	18·1	32·500.	Jets
·95	20·9	37·741.	Furnace
1·25	24·76.	44·570.	Furnace & Jets

PLATE VI.

TYNE MAIN COLLIERY.

Water Gauge or Drag of Air in Inches.	Velocity of Air through Workings in feet per Second.	Cubic feet of Air per Minute.	
·2.	15·27.	36·873.	Natural Ventilation.
·4	20·57.	49·574.	Steam Jet.
1·2	42·45	102·503.	Furnace.
1·25.	44·23	106·830.	Furnace & Jets.

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PLATE VIII.

KILLINGWORTH COLLIERY.

Mean Temp. Fah. Downcast	Mean Temp. Fah. Upcast	Velocity of Air in Downcast in ft. per Second.	Velocity of Air in Upcast in ft. per Second.	Cubic feet of Air per Minute.	in lbs. per Sq.re foot: Water Guage or Drag of Air.	in lbs. per Sq.re foot: Resistance of Shaft and Furnace.	
49°	65°	5·1	5·26	9·176	1·50	1·02	Natural Ventilation
,,	88°	16·00	17·26	28,888	3·30	38	Steam
,,	101°	18·1	19·96	32·500	4·20		Jets
,,	147°	20·9	24·93	37·741	5·70	3·36	Furnace
,,	164°	24·76	30·26	44·570	7·50	2·710	Furnace and Jets

PLATE IX.

TYNE MAIN COLLIERY.

Mean Temp. Fah. Downcast	Mean Temp. Fah. Upcast	Velocity of Air in Downcast in ft. per Second.	Velocity of Air through Cylinders in upcast in feet per Second.	Cubic feet of Air per Minute.	in lbs. per Sq.re foot: Water Gauge or Drag of Air.	in lbs. per Sq.re foot: Resistance of Shaft and Furnace.	
44°	62°	15·27	15·81	36·873	1·20	604	Natural Ventilation
,,	62°	20·57	21·11	49·574	2·4	2.	Jets
,,	262°	42·45	61·04	102·503	7·2	8·477	Furnace
,,	272°	44·23	64·48	106·830	7·5	8·65	Furnace and Jets

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PLATE X.

KILLINGWORTH COLLIERY.

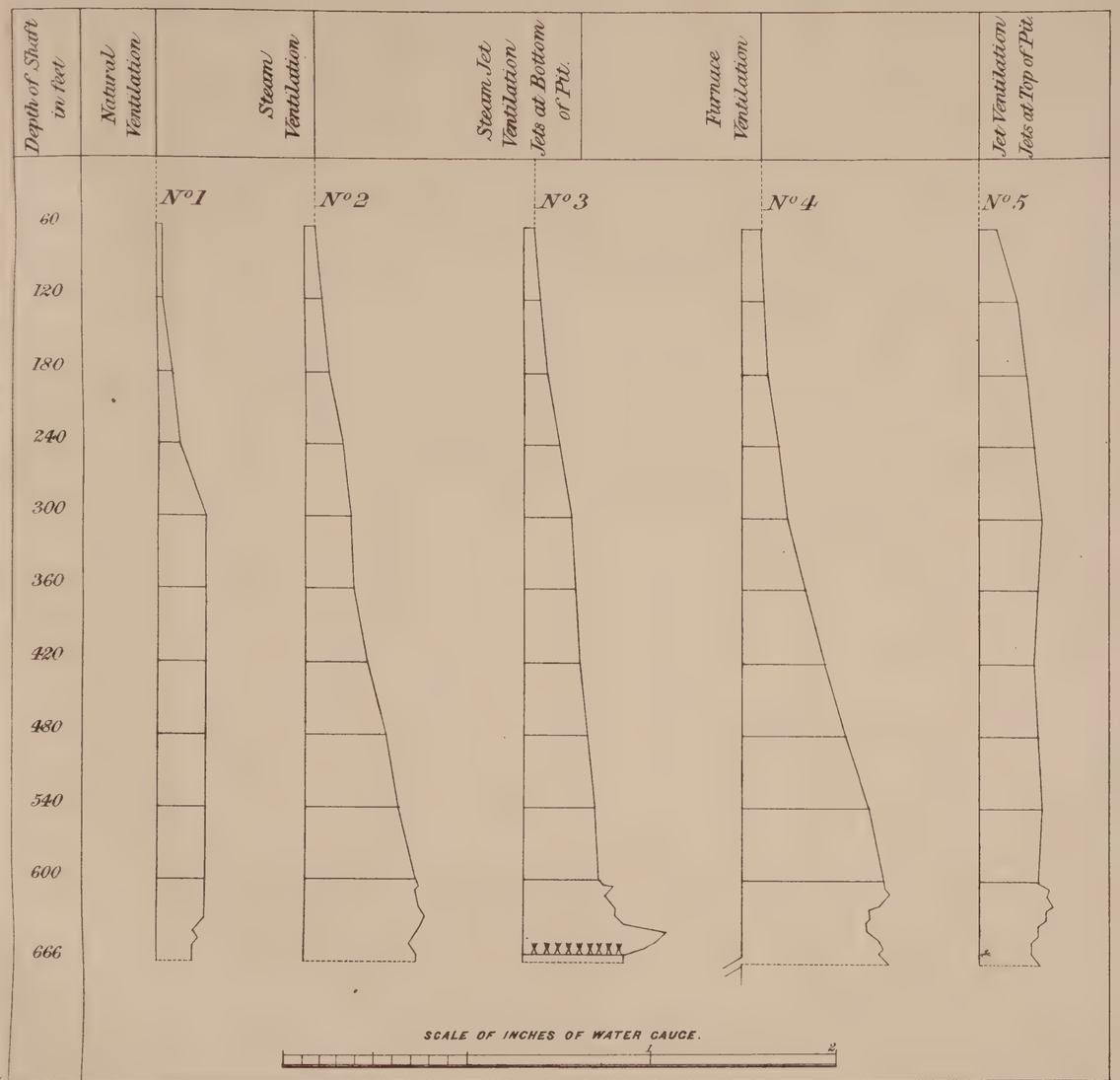
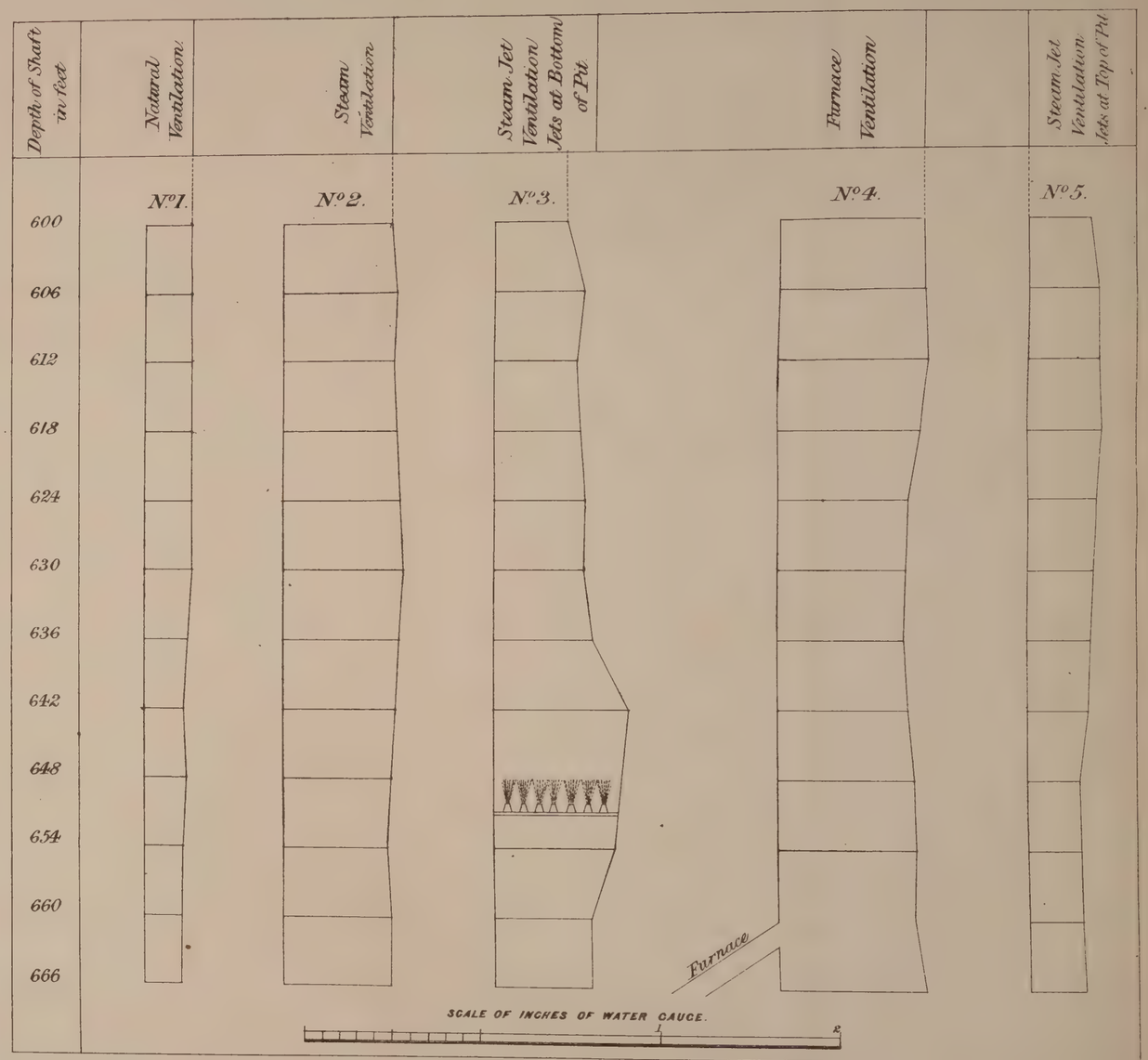


PLATE XI.

KILLINGWORTH COLLIERY.



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Appendix, No. 2.

PAPER delivered in by *J. K. Blackwell*, Esq.

A LIST of the Principal Colliery Explosions during Seven Years ending 1852, with the ascertained Cause of Ignition.

Date	Name of Pit or Colliery.	Where situated.	Proprietors.	Number Killed.	Gas, how Ignited.	Remarks.
1846:						
January	Toftshaw Pit	Hensworth, Yorkshire	Bowling Iron Company	5	naked light.	
"	Black Vein Pit	Risca, Monmouthshire	J. Russell & Co.	35	ditto	Candles generally used; lamps, if employed, not locked; other explosions in 1842, 1844, 1847, 1848, 1849, 1853.
April	Deepfields	Bilston, Staffordshire	Pemberton & Co.	5	ditto	A second explosion in week following, which burnt three persons severely.
May	Mynyddnewydd	Swansea	Swansea Coal Company	4	ditto.	
September	Bogle Hole Pit	Clyde Iron Works, Glasgow.		6	ditto.	
October	Littleton Hall Colliery	Westbromwich, Staffordshire.	Executors, late J. Horton	3	ditto	Several seriously injured.
"	Rainton	Near Durham	Marquis Londonderry	1	vent furnace	17 horses killed; occurred between Saturday night and Monday morning, only the furnace man in the pit.
November	Rounds Green Colliery	Oldbury, near Birmingham	G. Parker	19	naked light.	
"	Burgh Pit Coppul	Near Chorley	J. Hargreaves, jun.	8	ditto	32 killed, May 1852; naked lights in use in both explosions; men obliged to find their own lamps; a fiery and ill-ventilated pit.
December	Trubshaw Colliery	Church Lawton, Staffordshire.	J. Sutton & Co.	3	ditto.	
1847:						
January	Parr Colliery	St. Helen's, Lancashire	Bourne & Robinson	5	ditto	several severely injured.
February	Darley Main Colliery	Barnsley, Yorkshire		6	ditto	75 killed, January 1849.
March	Ardsley Main Colliery	ditto		73	ditto.	
"	Platt Bridge Colliery	Wigan, Lancashire	Price & Co.	3	ditto.	
"	Yew Tree Colliery	Kingswinford, Staffordshire	B. Gibbons	5	ditto	By gas drawn out of the workings on a naked light left in an air course by a collier who had quitted the pit.
May	New Hall Colliery	Beeston, near Leeds		9	ditto.	
June	Gerard's Bridge	St. Helen's Lancashire	Speakman Caldwell	8	ditto.	
"	Croft Pit	Whitehaven		4	ditto.	
June	Felling Main Colliery	Newcastle-on-Tyne		6	engine fire	Stated at inquest to have been occasioned by kindling one of the engine fires where gas had accumulated.
"	No. 4 Pit, Drumpellar	Airdrie, near Glasgow		3	naked light.	
July	Kirkless Hall Colliery	Wigan, Lancashire	Kirkless Hall Company	9	ditto	Several severely injured.
"	Abercanaid Pit	Plymouth, near Merthyr	Hill & Co.	3	ditto.	
November	Black Vein Pit	Risca, Monmouthshire	J. Russell & Co.	1	ditto	Several severely injured.

(*continued*)

List of the Principal Colliery Explosions during Seven Years ending 1852, with the ascertained Cause of Ignition—*continued.*

Date.	Name of Pit or Colliery.	Where situated.	Proprietors.	Number Killed.	Gas, how Ignited.	Remarks.
1847—*continued.*						
November -	Nant-y-glo - - -	- - Near Abergavenny, Monmouthshire.	J. & C. Bailey - -	7	naked light.	
1848:						
February -	Heathfield Colliery - -	- - Westbromwich, Staffordshire.	Salter & Raybould -	12	ditto.	
,, -	Victoria Pit - - -	- - Duckingfield, Ashton-under-Lyne.	Duckingfield Coal Company	7	ditto -	- - Explosions, November 1846, September 1848, February 1849.
March -	Eaglesbush Colliery -	Neath, Glamorganshire -	Penrose & Evans - -	20	ditto -	- - There have been several explosions in this colliery.
April - -	Victoria Iron Works -	Monmouthshire - -	- - - - -	7	ditto.	
May - -	Black Vein Pit - -	Risca, Monmouthshire -	J. Russell & Co. - -	3	ditto -	Several injured.
August -	Strandhill's Colliery -	Kingswinford, Staffordshire	Jones & Oakes - -	4	ditto -	Several injured.
,, -	Polka Pit, Murton Colliery	Near Durham - -	- - - - -	15	ditto.	
,, -	Albion Colliery - -	Hindley-green, Wigan -	J. F. Wood - - -	6	ditto -	- - Lives lost by an explosion, April 1849, and again 11th March 1852.
September -	Victoria Pit - - -	- - Duckingfield, Ashton-under-Lyne.	Duckingfield Coal Company	2	ditto.	
October -	Sencle Green Colliery -	St. Helen's, Lancashire -	S. Stock - - -	5	ditto.	
,,	Cleator Moor Colliery -	Whitehaven - - -	Hœmatite Iron Company -	30	ditto.	
1849·						
January	Darley Main Colliery -	Barnsley, Yorkshire -	- - - - -	75	ditto.	
February -	Victoria Pit - - -	- - Duckingfield, Ashton-under-Lyne.	- - - - -	5	ditto -	- - *See* note, February 1848, and above.
March -	Bird-in-Hand Colliery -	Eccleston, Lancashire -	- - - - -	7	ditto.	
,, -	Inn Hall Colliery - -	Wigan, Lancashire - -	Inn Hall Coal Company -	12	ditto.	
May - -	Werfa Colliery - -	Aberdare, Glamorganshire	- - - - -	5	ditto.	
June - -	Hebburn Colliery - -	Newcastle-on-Tyne - -	Easton & Co - - -	32	ditto -	- - 22 killed by an explosion, May 1852, being the third large explosion in this colliery.
,, -	Laffak Colliery - -	St. Helen's, Lancashire -	J. & T. Johnson - -	7	ditto.	
,, -	Friary Field Colliery -	Greatbridge, Dudley -	T. Morris & Son - -	15	ditto -	- - Several severely injured.
July -	Minera Colliery - -	Near Wrexham - -	- - - - -	9	ditto.	
August -	Cwm-Nant-Du Colliery -	- - Near Pontypool, Monmouthshire.	Pentwyn Iron Company -	5	ditto.	
,, -	Lletty Shenkin Colliery -	Aberdare, Glamorganshire	W. Thomas & Co. - -	52	ditto.	
1850:						
February -	Dudley Wood Colliery -	Near Dudley - - -	Pargeter & Darby - -	5	ditto -	- 11 killed by a former explosion in this pit.
,,	Gib Field Colliery - -	Chowbent, Lancashire -	R. Fletcher & Co. - -	5	ditto -	- - Gas driven out on a candle, placed too near; several others injured.
,,	Arley Mine Pit - -	Ince Hall Colliery, Wigan	- - - - -	4	ditto -	- - 50 killed in this pit, by explosion, March 1853.
March -	Rock Pit Haydock Colliery	St. Helen's, Lancashire -	Turner and Evans - -	13	ditto -	- - *See* note on explosion November 1850.
April - -	Town House Colliery -	Burnley, Lancashire -	- - - - -	6	ditto.	
,,	Usworth Colliery - -	Sunderland - - -	- - - - -	13	ditto.	
July - -	Common Head Pit - -	Airdrie, near Glasgow -	- - - - -	18	ditto.	
September -	Heys Colliery - - -	Ashton-under-Line - -	- - - - -	3	ditto -	- - Six killed by an explosion, March 1851. There has been great loss of life in this colliery.
October -	Bent Grange Colliery -	Oldham, Lancashire -	J. Butterworth - -	17	Fall of roof on Davy lamp.	- - 17 killed in this colliery by an explosion, caused by a naked light, 1 July 1853.
November	No. 13 Pit, Haydock -	St. Helen's Lancashire -	Turner & Evans - -	9	naked light	- - 13 killed in this pit, Nov. 1845. An explosion in the colliery in March 1850.
,,	Houghton Pit - - -	Newbottle, Durham -	Earl of Durham - -	17	- Evidence not fully conclusive.	- - It is not doubted that this was caused by a naked light.

List of the Principal Colliery Explosions during Seven Years ending 1852, with the ascertained Cause of Ignition—*continued.*

Date.	Name of Pit or Colliery.	Where situated.	Proprietors.	Number Killed.	Gas, how Ignited.	Remarks.
1850—*continued.*						
November -	Emroyd Colliery - -	Wakefield, Yorkshire -	Stansfield & Co. - -	2	- -	- - Mr. Morton says, "with the Davy lamp," but no evidence being given of this, its correctness must be doubted.
„	Victoria Colliery - -	Wakefield, Yorkshire -	Hudson & Co. - -	1	- -	- - The above remark applies also to this case.
December -	Middle Dyffrin - -	Aberdare, Glamorganshire	T. Powell - - -	13	naked light.	
„	Morfa Colliery - -	--Port Talbot, Glamorganshire.	Vivian & Sons - -	3	ditto.	
1851:						
February -	Fulledge Colliery - -	Burnley, Lancashire -	Hollgate & Cardwell -	4	ditto.	
March -	Victoria Pit - - -	Nitshill, near Glasgow -	Coats & Co. - - -	61	ditto.	
„	Heys Colliery - - -	Ashton-under-Lyne -	J. Kenworth & Brothers -	6	ditto -	- - *See* note on explosion in Sept. 1850.
April - -	Bottom Boat Colliery -	Wakefield, Yorkshire -	Charlesworth & Co. -	4	ditto.	
„	Gidlow and Swinley Colliery	Wigan, Lancashire - -	Executors, late J. Rylands	3	ditto.	
June - -	Ardsley Main Colliery -	Barnsley, Yorkshire -	Firth, Barber & Co. -	3	- -	- - The above note on Mr. Morton's statement, with regard to the explosion at Emroyd Colliery, applies to a similar one in this case.
July - -	Whitehall Colliery - -	Cradley, near Stourbridge	G. Dudley - - -	9	naked light.	
„	- - - - - -	Chorley, Lancashire - -	J. Blundell & Sons - -	4	ditto.	
August -	Washington Colliery -	Durham - - - -	- - - - -	38	ditto.	
„	Ubberley Colliery - -	Stoke, Staffordshire - -	J. Ridgway - - -	7	ditto -	- - Highly dangerous in 1850.
September -	South Sea Colliery - -	Wrexham, Denbighshire -	- - - - -	4	ditto.	
October -	Donnington Wood - -	Newport, Shropshire -	Lilleshall Iron Company -	2	- -	- - Mr. Dickenson says, by the Davy lamp, stating at the same time the facts of the case, which show that the lamp was not used with care.
„	Killingworth - - -	- - - - - -	- - - - -	10	naked light.	
November -	Great Lever Colliery -	Bolton, Lancashire - -	Earl of Bradford - -	3	ditto.	
December -	Bardsley Colliery - -	Ashton-under-Lyne -	J. Harrop - - -	4	ditto.	
„	Woodthorpe Colliery -	Sheffield - - -	J. Rhodes - - -	4	ditto.	
„	Warren Vale Colliery -	- - Near Wakefield, Yorkshire.	Charlesworth & Co. -	52	ditto.	
„	Ince Colliery - - -	Wigan, Lancashire - -	A. F. Halliburton - -	13	ditto.	
1852:						
January -	Norley Hall Colliery -	Pemberton, Wigan - -	Executors, J. Daglish -	6	ditto -	- - 12 killed by another explosion in March 1852.
„	Stoneclough Colliery -	Near Bolton, Lancashire -	Knowles & Scott - -	5	ditto -	- - Several severely injured.
„	Frimdon Colliery - -	Durham - - - -	- - - - -	3	ditto.	
March -	Albion Colliery - -	Hindley Green, Wigan -	J. F. Wood - - -	4	ditto -	-- *See* note on explosion in August 1848.
April - -	Norley Hall Colliery -	Pemberton, Wigan - -	Executors, T. Daglish -	12	ditto -	- - Second explosion in 1852.
May - -	Middle Dyffryn Colliery -	Aberdare, Glamorganshire	T. Powell - - -	65	ditto -	- - An explosion in this pit in December 1850.
May - -	Hebburn Colliery - -	Newcastle-on-Tyne - -	Easton & Co. - - -	22	ditto -	-- *See* note on explosion in this pit June 1849.
„	Coppul Colliery - -	Chorley, Lancashire -	J. Hargreaves, jun. - -	36	ditto -	-- An explosion in this colliery in November 1846.
June - -	Seaton Colliery - -	Durham - - -	- - - - -	6	ditto.	
November -	Bryndu Colliery - -	Pyle, Glamorganshire -	J. Ford & Son - - -	4	ditto.	
December -	Elsecar Colliery - -	Barnsley, Yorkshire -	Earl Fitzwillim - -	10	ditto.	

The foregoing List contains all the principal accidents during seven years; the number of fatal cases to which it extends is 1,099. The minor accidents, and cases not terminating fatally (both of which are numerous), have been omitted in the investigation. It has been compiled from personal investigations, printed reports, and special inquiries, in all doubtful cases.

J. Kenyon Blackwell.

Appendix, No. 3.

PAPER delivered in by *T. E. Forster*, Esq.; 25 July 1853.

Seaton Delaval Colliery, 18 May 1853.

Appendix, No. 3.

FIRST SERIES of EXPERIMENTS made whilst Steam Jets were in full operation, and the only Ventilating Power (save that due to heat of boiler fires) 33 Jets, each 3 ft. 16 in., and three Boilers.

Temperature at surface, 62 degrees Fahrenheit.
State of weather, fine, cloudless; wind, E.S.E.
Temperature at bottom of downcast, 51½ degrees.
Depth of downcast, 636 feet; upcast, the same.
Barometer at bottom of downcast, 30·16.

First Experiment made upon Engine Plane, about 1,000 yards from shaft, and at same level:

Temperature of air at this point, 55 degrees.
Mean sect. area of drift (arching), 70 square feet.

(*a*) With a distance of 30 feet, the velocity of gunpowder smoke gave, as a mean of three trials - - - - - - - 2⅔ seconds.

(*b*) With a distance of 60 feet, same area, velocity - 5⅚ „

(*c*) With a distance of 90 feet, same area, velocity - 9 „

Cubic feet of air per minute due to each:

For 30 feet - - - - - -	47,250
For 60 feet - - - - -	43,200
For 90 feet - - - - - -	42,000

Second Experiment, made in Victoria Drift, about 60 yards from downcast; same level:

(*a*) With a distance of 30 feet, mean sect. area - - 58 square feet.
Velocity, mean of four trials - - - 4⅜ seconds.
Cubic feet of air per minute - - - - 23,863.

(*b*) With a distance of 60 feet, mean area - - - 56½ square feet.
Velocity; mean of three trials - - - 10½ seconds.
Cubic feet of air per minute - - - - 19,683.

(*c*) With a distance of 120 feet and sect. area of 57 square feet—
Mean velocity - - - - - - - 24 seconds.
Cubic feet of air per minute - - - - 17,100.

Third Experiment, being measurement of Air consumed by Boiler Fires:

Mean sectional area - - - - -	57½ square feet.
Distance - - - - - - -	30 feet.
Velocity; mean of three trials - - -	6 seconds.
Cubic feet of air per minute - - - -	17,250.
Temperature of air - - - - - -	51½ degrees.

SUMMARY.

	30 ft. dist.	60 ft.	90 ft.	120 ft.
Engine plane	47,250	43,200	42,000	—
Victoria	23,863	19,683	—	17,100
Boiler fires	17,250	—	—	—
	88,363			

The Second Series of Experiments made in the Return Air Drifts, to test the accuracy of the above.

Fourth Experiment, being measurement of Air in one of North Pit returns; part of Engine Plane Column:

(*d*)
- Mean sect. area of drift - 57 square feet.
- Distance - 30 feet.
- Mean velocity - 2½ seconds.
- Cubic feet of air per minute - 41,040.

(*e*)
- Mean sect. area of drift - 56½ square feet.
- Distance - 60 feet.
- Mean velocity - 5¾ seconds.
- Cubic feet of air per minute - 35,373.

Fifth Experiment, being measurement of Air in second Return Drift for North Pit Engine Plane Column:

- Mean sect. area of drift - 32½ square feet.
- Temperature, 60½° - Distance - 30 feet.
- Mean velocity - 7 seconds.
- Cubic feet of air per minute - 8,356.

Sixth Experiment, being measurement of Air in Victoria Return Drift:

- Mean sect. area - 35⅓ feet.
- Distance - 60 „
- Mean velocity - 5 seconds.
- Cubic feet of air per minute - 25,440.

The temperature at this point is raised to 65° by the smoke from a small engine used to pump water.

Comparison of Intake and Return Measurements:

		Cub. ft.	Temp.
Engine plane		47,250	55
1st Return from same	41,040		
2d Ditto	8,356		
		49,396	60
Difference		2,146	5½

As air expands for every degree of heat $\frac{1}{480}$°th part of the bulk it would occupy at 32°; 47,250 at 32° would occupy a space represented by $47{,}250 \left(\frac{480}{480+(55-2)}\right) = 45{,}085$ cubic feet, volume at 32°, and from 32° to 60½° is 28½°; therefore $\left(\frac{45{,}085}{480}\right) 28\frac{1}{2} = 2{,}676$ increase, which added to the volume at 32° or $45{,}085 = 47{,}761$, the volume to which the quantity measured on the engine plane should expand by the time it reached the point where measured in the return; but the actual quantity measured in said return is 49,396, making a difference of 1,635 cubic feet. Now, if we consider that gas is given off, not only by the coal, but also by the men and horses working in the mine, this small quantity of 1,635 cubic feet will necessarily be still further reduced, and thus leave a remarkable coincidence between the two measurements, and is certainly a most satisfactory verification of the accuracy of both series of experiments.

By making a similar comparison of Victoria, we have

	Cub. ft.	Temp.
Intake	23,863	51½
Return	25,440	65
Difference	1,577	13½

Appendix No. 3.

$23{,}863\left(\frac{480}{480+(51\frac{1}{2}-32)}\right) = 22{,}932$, volume at 32°, and

$\left(\frac{22{,}932}{480}\right)(65-32) =$ - 1,577 increase from 32° to 65°;

wherefore 22,932 + 1,577 = 24,509 by calculation,
and 25,440 by measurement.

Making a difference of - 931 cubic feet only.

Seventh Experiment, made to ascertain the effect produced upon the Mine Currents, by opening the separation doors leading to boiler fires, and allowing the said fires to consume fresh air, *ad libitum*:

Biram's Patent Anemometer used.

Doors shut and fires fed by a scale, being the method hitherto employed; 100 feet on dial passed over in - - - - - 24 seconds.
Doors full open, same distance passed over in 19 seconds.

Showing a gain to the workings of the mine by keeping the doors open in the ratio of 24 to 19.

These last experiments made in Victoria Drift.

During all the foregoing experiments the steam jets were kept at work, and the water-gauge indicated a difference of pressure amounting to 1½ inches = 8 lbs. per square foot.

Three boilers were used for the engine and jets together:

Consumption of coal - - -	Day time - -	210 cwt.
" - - -	Night - - -	52 ½

Engine draws 2,200 yards down a declivity of 12 feet in all; nearly the whole of which fall is upon the first 600 yards, the remaining 1,600 yards being about water level.

Eighth Experiment, made without the jets, at 6 ½ p. m.; the jets having been quiescent since 5 p. m. At 6 ½ the water-gauge was examined, and found to indicate a pressure of 1 inch only = 5 ¾ lbs. per square foot:

First measurement made on engine plane.

(*f*)

Mean sect. area - - - - - - - -	70 square feet.
Distance - - - - - - - -	30 feet.
Mean velocity - - - - - - - -	5¾ seconds.
Cubic feet of air per minute - - - -	21,913.

(*g*)

Mean sect. area - - - - - - - -	70 square feet.
Distance - - - - - - - -	60 feet.
Mean velocity - - - - - - - -	11⅓ seconds.
Cubic feet of air per minute - - - -	22,235.

Ninth Experiment made in Victoria, at 7½ P.M. No jets:

(*h*)

Mean sect. area - - - - - - - -	58 square feet.
Distance - - - - - - - -	30 feet.
Mean velocity - - - - - - - -	7 seconds.
Cubic feet of air per minute - - - -	14,914.

(*i*)

Mean sect. area - - - - - - - -	56½ square feet.
Distance - - - - - - - -	60 feet.
Mean velocity - - - - - - - -	14 seconds.
Cubic feet of air per minute - - - -	14,528.

Comparison of the Two Series:

Available air passed through the mine, with jets at

	Engine Plane.		Victoria.		Total.
Work - - -	47,250	-	23,863	=	71,113.
Without jets - -	21,913	-	14,914	=	36,827.

Then, as 71,113 : 36,827 :: 100 : 51¾; that is to say, by using 33 jets of steam at a pressure of 35 lbs. per square inch in the Seaton Delaval Mine, the additional quantity of air

air so obtained amounts to 34,286 cubic feet per minute, being 48¼ per cent. of the whole, or an increase of 93 per cent. upon the quantity obtained without the jets; and

Appendix, No. 3.

By the present system of steam-jet ventilation upon the available quantity of 71,113 cubic feet, there is due to heat - - - - - - - - - -	51¾ per cent.
Ditto to mechanical action of jets - - - -	48¼ „
	100

Seaton Delaval Colliery, May 1853.

SUNDAY MEMORANDUMS RELATING TO VENTILATION.

Upcast and Downcast, each 8 feet diameter, and 636 feet deep.

Cubic content of each, in feet, 31,959.

Temperature, top of downcast, 62° } Mean, 56¾°, say 57°.
Ditto bottom ditto 51½° }

Mean temperature of upcast, 136°.

Barometer at bottom of downcast, 30·16.

Weight of a cubic foot of air at 60°, 536 grains, of 7,000 to the pound avoirdupois.

Weight of descending column, $\frac{31,959 \times 536}{7,000} = 2,447$ lbs.

To find the weight of ascending column, we must first find the increase in volume due to a rise in temperature from 57° to 136°; viz., 79°.

Thus, by the known formula, we know that—

31,959 at 57° = 30,377 at 32°; and

$\left(\frac{30,377}{480}\right)$ 79 = 5,000, which added to 31,959 gives 36,959 volume at 136°.

Then, $\frac{31,959 \times 2,447}{36,959} = 2,116$ lbs. weight of ascending column.

2,447 — 2,116 lbs. = 331 lbs., which divided by sectional area of shaft, or 50¼ square feet, gives 6·58 lbs. per square foot for the rarefying power; and this, again, is equal to 1·20 inches water-gauge.

By comparing this with No. 8 Experiment, of May 18, we find that the actual water-gauge was 1·00 inch, or 5·45 lbs. per square foot without the jets.

To find the ventilating column due to the effect of heat alone—

31,959 : 636 :: 36,959 : 735; and

735 — 636 = 99 feet for ventilating column.

Total Quantity of air driven up the upcast by the united efforts of jets and boiler fires,

Is 88,363 cubic feet per minute.

The weight of this will be $\frac{88,363 \times 536}{7,000} = 6,766$ lbs. per minute,

Or 3·02 tons = 181 tons per hour = 2,172 tons in 12 hours; which is more than double the weight of coals drawn by two 60-horse engines in the same time.

Coals consumed, 210 cwt. in 12 hours = 33 lbs. per minute.

88,363 cubic feet will expand, in the upcast, at a mean of 136° to 102,862 cubic feet per minute; and this quantity divided by the area of shaft, gives a velocity of—

2,047 feet per minute; or,
34 feet per second; or,
23½ miles per hour.

N. B.—Deduct one-third from feet per second, and the result is miles per hour, very nearly.

Appendix, No. 3.

To find the "drag" of the air:

Actual velocity in upcast = 34 feet per second, of which quantity $51\frac{3}{4}$ per cent. is due to rarefaction; viz. 17·59 feet per second.

The theoretical velocity in the upcast is expressed by

$$v = 8\sqrt{\frac{(h\,t' - t')}{450+t}}$$

where v = velocity in feet per second of air at t'

h = depth of shaft in feet.

t' = temp. of upcast.

t = temp. of downcast.

Applying this formula to our case, we have

$$v = 8\sqrt{\frac{636\,(136° - 57)}{450+57}} = 79{\cdot}6 \text{ feet per second;}$$

i.e. if there were no resistance, we should have in the upcast a velocity of 79·6 feet per second; whereas the actual velocity obtained from rarefaction is only 17·59 feet per second; or, in other words, the

Velocity realised is - - -	22 per cent.
Velocity absorbed by resistance -	78 per cent.

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I N D E X.

[In this Index the *Figures* following the Names of the Witnesses refer to the Questions of the Evidence; and those following *Rep.* i. *App.*, *Rep.* ii. *App.*, and *Rep.* iii. *App.*, to the page of the Appendices of the several Reports.]

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ACCIDENTS. Reference to the enormous annual loss of life among the workmen in thick coal collieries, worked under the old systems, *Dickinson* 28——Statement of the number of accidents which have occurred in coal and other mines in Belgium, in the five years ending 1849, and also in the years 1851 and 1852, showing the number of lives lost, *ib.* 421——Tabular statement of the accidents in coal mines in England in 1851 and 1852; comparison between the loss of life in Belgium and England, *ib.* 423–427——Return of the loss of life by colliery accidents in England, Wales, and Scotland, during the years 1851 and 1852, as reported by the inspectors of coal mines, *ib.* 428——Statement of the accidents which occurred in the coal mines of Great Britain in 1851 and 1852; observations thereon, *Mackworth* 480, 481——Comparative statement with respect to the number of men employed, and the number of accidents, in England, France, and Belgium, showing that the excess of deaths is considerably more in England than in the other countries, *ib.* 681–683.

When accidents occur, the proprietor of the mine is obliged to send notice to the Secretary of State; it would be very advantageous if notice was at the same time sent to the inspector, as it would enable him to be early at the scene of accident, *Dickinson* 948–957——The absence of accidents, as a general rule, is the best test of a well-managed and ventilated colliery, though not invariably the case, *ib.* 1209——A better knowledge of the cause of accidents would aid much towards their prevention, *Wood* 3901——Evidence relative to reports by witness and others on explosions in several mines, showing the cause of the accidents and the state of the ventilation in those mines; suggestions for improving the ventilation, *Blackwell* 4043–4077. 4092 *et seq.*

Instructions and questions relative to the Parliamentary Committee, now sitting, to inquire into the causes of accidents in coal mines, *Rep.* i. *App.* 135——Tabular view of the number of accidents causing death in the coal mines of Great Britain in 1851 and 1852, *ib.* 136——Tabular statement of the lives lost in the coal mines of Great Britain in the years 1851 and 1852, *ib.*——Comparative loss of life in coal mines per 10,000 persons employed in and on the mines per annum on 460,000 persons in England, 256,760 in Belgium, and 73,275 in Westphalia, *ib.* 137.

See also *Ascent and Descent of Mines. Belgium. Explosions. France. Inspection of Mines*, I. 1. *Naked Lights. Prussia. Scotland.*

After-damp. In all cases of explosions, where large numbers of lives have been lost, the bulk of those deaths have resulted from the after-damp, *Blackwell* 4047–4052; *Forster* 4599, 4600.

Air-pressure Gauge. Witness has invented an air-pressure gauge; description thereof, and mode in which applied, *Mackworth* 1560, 1561.

Air-ways. Witness sees no greater difficulty in ventilating a mine with air-ways in the solid coal than with air-ways maintained by gobbing, *Dickinson* 23——Regulation with respect to the air-courses in mines in Belgium, *ib.* 201——Observations relative to the necessity of air-ways being of a sufficient size; the want of proper capacity in the air-ways is the root of all imperfect ventilation, *Dickinson* 1149–1152; *Jude* 1722–1724; *Swallow* 2619–2628. 2647–2652; *Blackwell* 4030–4036; *Forster* 4830——Suggestions as to the capacity and size of the air-ways, and the best mode of carrying the air through the workings to the up-cast shaft, *Mackworth* 1579–1581——A sufficient amount of ventilation can be afforded to every mine, provided proper attention is paid to the return air ways, *Henderson* 2333. 2342, 2343.

Reports, 1852-53—*continued.*

Air-ways—continued.

The obstruction of the air-passages round the remote workings is the main cause of the loss of life in collieries; mode suggested for remedying this evil, *Swallow* 2577-2591. 2619-2624——It is very necessary to pay great attention to the size of the air-ways, for the purposes of ventilation, and to distribute the air by a system of splitting in sufficient quantities throughout the pit, *Gray* 3001-3008——Due care should be taken to keep the air-ways in proper order, and of a sufficient size; there cannot be too much air in a mine, *Tetlow* 3302-3304——Generally speaking, sufficient attention is not paid to the capacity and the size of the air-ways; they are far too small, *Forster* 4583-4585.

See also *Distribution of Air.* *Shafts.*

Airometers. Plan and section of single-acting airometers, *Rep.* i. *App. Plan* (F.)

Alloa Colliery. Remarks relative to the fire in the mine at Alloa, Scotland, being extinguished by the injection of carbonic acid gas into the mine by means of the steam-jet, after all other means had failed, *Cayley* 1523-1536. 1542.

Anemometers. Witness does not consider that the self-registering anemometer could be depended on as indicating the state of the ventilation, because the air-ways may be altered from time to time so as to affect very materially the results indicated by it, *Mackworth* 608-628. 643-652——No one instrument can test the distribution of the air; unless there is an anemometer in every working point, it cannot be ascertained that the air is thoroughly distributed, *ib.* 667-676——Supposing the anenometer to be placed close to the end of the brattice, and the brattice was not lengthened as the heading advanced, the danger to the workmen would be increasing whilst the indications of the instrument remained the same, *ib.* 671-676——Although a self-registering anemometer at the bottom of the up-cast and at the bottom of the down-cast would be no test of distribution, yet it would be a test of the amount of air entering the mine to be distributed, *ib.* 867-871 —— Opinion that the Government inspector could not rely on the anemometer as a test for what quantity of air was passing through the mine, provided his visits were only once a month; a badly conducted overman could tamper with the anemometer, and render it an insufficient test to be relied on, *Dickinson* 1188-1208; *Jude* 2242, 2243; *Forster* 4825-4828——Byram's anemometer will measure about a fortnight, but it would take an inspector to each large colliery to read off the numerous measurements that would be necessary, *Dickinson* 1188-1208.

Opinion that the self-adjusting anemometer is not a proper test of the ventilation, *Swallow* 2592-2594——Objections to a recommendation of the Committee of 1852, that there should be a self-registering anemometer in every pit, and that it should be so placed that the inspector on his periodical visits might know the rate at which the current of air had been passing through the mine in his absence, *Wood* 3666-3678 ——The best regulator is an anemometer placed near the furnace of the pit; a record of its state should be reported at short intervals to the manager of the mine, *ib.* 3668-3673——A registering anemometer might be placed in every mine out of the reach of all parties disposed to tamper with it; mode by which this object should be attained, *Gurney* 4299-4305—— Witness prefers the use of gunpowder smoke to the anemometer in measuring the quantity of air in a mine, *Forster* 4818-4829.——*See* also *Water-gauge.*

Approach of Danger. Instruments seem to be very little used in any of the continental mines as a means of indicating danger, *Dickinson* 183.

See also *Danger Signals.* *Water-gauge.*

Ardsley Main Colliery. Reference to an explosion in the Ardsley Main Colliery, near Barnsley, by which seventy-three men were killed; most of these men could have got into the air-passages if there had been any unobstructed, *Swallow* 2573-2585——Remarks on the subject of an explosion in March 1847 at Ardsley Main Colliery, by which seventy-three persons were killed; systems of working and of ventilation pursued; the after-damp was the great cause of death, *Blackwell,* 4131.

Artificial Ventilation. Opinion that it is most desirable that artificial ventilation should be made compulsory in all collieries; more injury is caused to life and health by the want of ventilation in non-fiery mines than by all the accidents by explosions, *Mackworth* 782, 783——Artificial ventilation should be enforced in every colliery, but no particular system should be specified, *Swallow* 2521-2531——In Northumberland and other districts where the pits are very deep, artificial ventilation is absolutely necessary, *Blackwell* 3942.

See also *Furnace Ventilation.* *Mechanical Ventilators.* *Natural Ventilation.* *Steam-jet Ventilation.*

Ascensional Ventilation. The great principle of the ventilation of the mines in Belgium is that of ascensional ventilation, and throughout the Continent the greatest stress is laid on that point; by keeping all the air-courses in a mine gradually inclined upwards to the up-cast shaft, even a blower of gas which comes off finds its own way to the surface, *Mackworth* 714——The distribution of air is very defective in the mines in England; how

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Ascensional Ventilation—continued.

how far it would be possible to introduce the ascensional ventilation as adopted in Belgium, *Mackworth* 784–798——Opinion that the ascending ventilation in use in Belgium should not be made altogether compulsory in collieries in England, *ib.* 1460, 1461 —— With strictly ascensional ventilation much smaller quantities of air are necessary for safety, *ib.* 1503.

Ascent and Descent of Mines:

1. *Generally.*
2. *Frequency of Accidents occurring during the winding of the Men up and down the Pits.*
3. *Suggestions for the Prevention of these Accidents.*

1. *Generally:*

Remarks relative to the ascent and descent of mines; in Belgium ropes are forbidden, and ladders, which are considered safer, are resorted to, *Dickinson* 428–430——There would be great difficulty in getting the miners in England to ascend or descend the deep pits by ladders; it must be very unhealthy, the work being so very laborious, *ib.* 428—— It would be more destructive to life if the men were compelled to ascend and descend the pits by ladders in this country, *Mackworth* 690——Very few accidents have arisen from the slides being out of order in the north of England, *Jude* 2183, 2184.

2. *Frequency of Accidents occurring during the winding of the Men up and down the Pits:*

Accidents frequently occur, by which men are killed by pieces of coal falling from one ascending bucket while the men are descending in the empty one; the Legislature should interfere to prevent the men being let down the pit while the materials are coming up, *Dickinson* 1227–1230. 1259–1281——Evidence generally with respect to the accidents which occur to the men in ascending and descending the pits, but might be somewhat prevented by decreasing the speed at which the men are drawn up, *Jude* 2134–2182—— Many accidents arise from the employment of persons not properly qualified in winding the miners up and down the shafts, *Swallow* 2787–2795——Evidence on the subject of winding the men up and down the shafts; there has been only one accident during this process at the Morfa colliery; the loss of life on this point is entirely attributable to carelessness, *Gray* 3092–3112——Probability of accidents occurring through carelessness or defective regulations in winding the men up and down the pits; suggestions on this point, *Tetlow* 3167–3237——Remarks as to the occurrence of accidents during the process of winding the men up and down the shaft; they could be wound up with perfect safety at a speed of 300 feet per minute, *Wood* 3696–3705——But very few accidents occur in the north of England in winding persons up the shafts, *Forster* 4621, 4622.

3. *Suggestion for the Prevention of these Accidents:*

It is quite practicable to have a cage to drop down on the pit as an effective precaution against loss of life by falling down pits, which is very common, *Dickinson* 430, 431——Opinion that with proper attention accidents would not occur from the use of ropes as a means of ascent and descent; witness has more faith in good tackle and in good winding arrangements than in Mr. Fourdrinier's patent, *ib.* 431–434——Great number of accidents which occur in winding persons up and down the pits; the use of guides of some sort should be made compulsory in all working pits, *ib.* 1210–1223——Precautions which should be enforced to prevent accidents in ascending and descending mines, *Mackworth* 1595——Remarks as to the employment of patent cages, with guides on for ascending and descending the pits in the north of England; there has been less loss of life since the cages have been in use, *Jude* 2140–2154——As regards the winding up and down the pit, the suggestion that the men should pull the bell-rope is quite impracticable; opinion that the men are generally wound up too fast, *Henderson* 2349–2360.

The custom of letting a man down the shaft while a full waggon of coals is going up is very dangerous, and should be prohibited, *Swallow* 2797–2799; *Forster* 4626–4628—— Accidents have arisen through the men not being allowed sufficient time to get out of the box when let down; it should be imperative that the engine-man receive some signal from the bottom before he starts the engine back again, *Tetlow* 3167–3172. 3182–3200—— Too many men are frequently let down the pit at the same time; the number should be limited to four, *ib.* 3173–3181. 3202–3215. 3219–3229——In the event of any danger arising during the ascent or descent of the men, it is quite practicable to give a signal to the engine-man if the engine is not winding too quickly, *ib.* 3230–3232—— With respect to the process generally of winding up and down the pit, certain rules should be established on which the inspectors and coalowners should act, *Wood* 3714–3717——Suggestion that covers should be placed on the tops of the cages used by the men in ascending and descending the pits, *Forster* 4621–4640——No persons should be employed as engineers in winding men up and down a pit under eighteen years of age; in the north of England they are always upwards of twenty, *ib.* 4644–4648.

See also *Fourdrinier's Apparatus. Machinery. Shafts.*

Reports, 1852-53—*continued.*

Atmosphere. Observations generally with respect to the effects of changes in the pressure of the atmosphere upon the ventilation of mines; the increase in the temperature diminishes the amount of the ventilation, *Dickinson* 116-128——In all cases where the state of the atmosphere is such as to produce a halo round the candle, the quantity of air should be doubled to prevent the danger of an explosion, *Mackworth* 852-861.

B.

Barnsley District, Yorkshire. Dangerous mode of working coal in the Barnsley district, Yorkshire, where explosions are very frequent, and are to be attributed to sudden discharges of gas from the goaves; papers on these explosions delivered in, *Blackwell,* 4061-4065. 4131——The use of the Davy lamp should be rendered compulsory throughout the Barnsley district, and naked lights should be abolished altogether, *ib.* 4064.

See also *Ardsley Main Colliery. Elscar Colliery.*

Barometer. Remarks as to the barometer as a means of indicating danger; the fall of the barometer would indicate the necessity for greater vigilance on the part of the persons having charge of the ventilation, *Mackworth* 544-546. 568.

See also *Explosions.*

Bedlington Colliery. Letter received by witness from the workmen in the Bedlington Colliery, dated 7 March 1853, complaining of the bad state of the mine; this letter witness forwarded to the inspector, who visited the colliery, and suggested various improvements, which have since been carried out, *Jude* 2184-2200.

Belgium. Sketch of the system of long work in the steep coal seams in Belgium; section of workings in a seam dipping perpendicular, *Dickinson* 129, 130——Remarks relative to the depth of shaft in some of the Belgian mines; extent of the workings, and number of men employed, *ib.* 144-147——In Belgium 2½ per cent. of the profits arising from the coal mines is payable to the Government; it is an important part of the duty of the inspectors to look after the interests of the Government, *Dickinson* 233, 234. 244, 245; *Mackworth,* 701. 710, 711——In Belgium the Government stand in a position similar to the lessors of mines in this country, *Dickinson* 448-452——Perfect system of management in the Belgian mines, *Mackworth* 683——The mines are better laid out than they are in England, *ib.* 712——Decrease in the number of deaths from accidents in the mines in the last fifteen years, *ib.* 1513——The use of machinery is very extensive in the mines of Belgium; the furnace would be dangerous, as the shafts are commonly lined with wood, which might be ignited by the furnace, *Blackwell* 4041, 4042——List of accidents in coal mines in the province of Hainault, comprising the two districts of Mons and Charleroi, *Rep.* i., *App.* 137.——Plan of the colliery of Boussu and St. Croix St. Clare, near Mons, *ib.* 141.

See also *Accidents. Air-ways. Ascentional Ventilation. Ascent and Descent of Mines. Closing of Mines. Dickinson, Mr. Discipline. Distribution of Air. Fire-damp. Furnace Ventilation,* 4. *Hainault. Inspection of Mines,* II. 1. *Long-work System. Management of Collieries. Mechanical Ventilators. Mueseler's Lamp. Naked Lights. Rules and Regulations. Safety Lamps,* 3. 5. *Steam-jet Ventilation,* 3. *Ventilation.*

Benefit Societies. Remarks relative to the benefit societies and sick clubs existing among the workmen in coal mines; insufficiency of these societies to meet the case; it is very desirable that some provision should be made for the widows and orphans, which is not the case at present, *Dickinson* 1369-1396——Subscriptions are paid by the men towards a fund in the event of sickness, &c., but they would object to provide any funds for the support of their widows and orphans in case of their own accidental deaths, *Wood* 3912-3916.

Bentgrange Colliery. Remarks relative to the steam-jet system of ventilation, as adopted at the Bentgrange Colliery, at Oldham, *Dickinson* 1124, 1125.

Black-damp. Reference to the inefficiency of the ventilation in some mines; the health of the miners is very prejudicially affected by the existence of black-damp, *Tetlow* 3340-3344.

Blackwell, J. Kenyon. (Analysis of his Evidence.)—Mining engineer; has had considerable experience in the direction of mines, 3926, 3927. 3932, 3933——In 1849, witness was commissioned by Government to report upon the state of the mining districts, with a view to the prevention of accidents, 3928-3931——One of the principal recommendations in that report was that in all fiery mines the Davy lamp should be compulsorily used, 3930. 4066-4077. 4082, 4083. 4090-4096——Another recommendation was, that mining schools should be established, 3930——In consequence of the different characters of coal mines, and the different systems of working, no general law can be made applicable to the entire country, 3934-3938——Natural ventilation is sufficient for the mines in South Staffordshire, except in the summer months, 3939-3941. 4036.

In

Reports, 1852-53—*continued.*

Blackwell, J. Kenyon. (Analysis of his Evidence)—*continued.*

In Northumberland and other districts, where the pits are very deep, artificial ventilation is absolutely necessary, 3942——The particular mode of ventilation should be left to the coalowners, the inspectors seeing that sufficient air was provided and properly distributed, 3943——Remarks as to the quantity of air required by each miner; five hundred cubic feet per minute is more than sufficient under ordinary circumstances, 3943-3948——Sudden escapes of accumulated gas frequently take place under the old system of stall-working; objections to this mode of working, and preference given to the long-work system, 3946-3965——In cases of explosions, the stoppings and doors are generally blown away; they should be rendered much stronger and more secure, 3961-3966.

Mode suggested for reducing the wastes under the pillar-and-stall system, so as not to leave large deposits of gaseous matter in the mine, 3964, 3965——Opinion that doing away with doors altogether would be attended with a great saving of life in cases of explosions, 3966. 3969-3971——In Northumberland and Durham generally, and in the collieries under Mr. Wood, there is great freedom from accidents; this is attributable to the practical and scientific attainments of the engineers of that district, 3966-3969. 3972, 3973——Description of the Lancashire collieries, and mode of working pursued therein; sufficient attention is not paid to dividing the mine into districts, and to splitting the air, 3974-3983.

Reference to an explosion at Nitshill Colliery, in Scotland; opinion that this mine could not have been properly ventilated, as stated in the report of Mr. Dunn, the Government inspector; paper on the subject delivered in, detailing the system of ventilation adopted, &c.; sixty-one persons were killed by this explosion, 3984-3993. 4131——With respect to the coal fields of South Wales, they are almost exclusively worked on the pillar-and-stall system; defective state of the air-ways in these collieries, and consequent occurrence of accidents, especially in the thick coal seams, 3994-4002. 4006-4008——The managers of the South Wales mines are as a class very deficient in their attainments, 4003——Imperfect state of the ventilation in the Yorkshire mines, 4004——The viewers in Yorkshire are less educated than those in the north of England, 4005——The explosions in South Staffordshire are attributable to a want of proper air-ways, and of due precautions on the part of the workmen, 4009-4011. 4028-4036.

Remarks on the North Staffordshire mines; the ventilation is ordinarily imperfect, 4012-4031——This was especially the case at the Ubberley Colliery, where an explosion occurred some few years since, 4014-4021——The largest collieries are the best ventilated, because they are managed by men of a superior class, 4027——Observations relative to the necessity of air-ways being of a sufficient size; the want of proper capacity in the air-ways is the root of all imperfect ventilation, 4030-4036——How far the Davy lamp is used in the Staffordshire mines; it is inefficient in the working of seams thirty feet in thickness, as it cannot cast the light high enough; suggestion for the working of these seams by long work in separate stages, in lieu of the present pillar-and-stall system, 4037. 4039, 4040.

Reference to the ventilation of a colliery in South Wales by M. Struvè's machinery, as recommended by witness, in lieu of the furnace; success of this recommendation, 4037, 4038——The use of machinery is very extensive in the mines of Belgium; the furnace would be dangerous, as the shafts are commonly lined with wood, which might be ignited by the furnace, 4041, 4042——Evidence relative to reports by witness and others on explosions in several mines, showing the cause of the accidents, and the state of the ventilation in those mines; suggestions for improving the ventilation, &c., 4043-4077. 4092 *et seq.*——The explosion at the Haswell Colliery in 1845 was occasioned by the insufficient separation of the ingoing from the outgoing air; seven-eighths of the loss of life occurred from the after-damp; report on the subject delivered in, 4047-4052. 4131——In all large explosions the after-damp is the main cause of death, 4047-4052.

Remarks on the explosion in 1845 at the Jarrow Colliery; a bratticed shaft, as used there, is extremely insecure; reports on this explosion handed in, 4053-4056. 4131——Reference to several other collieries where explosions have occurred, which are mainly attributable to the insufficient separation of the air-currents from the doors, and from the want of proper stoppings, 4056-4060. 4064, 4065——Dangerous mode of working coal in the Barnsley district, Yorkshire, where explosions are very frequent, and are to be attributed to sudden discharges of gas from the goaves; papers on these explosions delivered in, 4061-4065. 4131——The use of the Davy lamp should be rendered compulsory throughout the Barnsley district, and naked lights should be abolished altogether, 4064——Considerable security is afforded in all mines by the use of the Davy lamp; concurrence with the views of Mr. N. Wood on this subject; when the lamp becomes filled with flame, the miner should consider it a warning to cease working, 4066-4077. 4082, 4083.

Objections to Mr. Wood's suggestions for educating the officers of mines by means of a national scientific institution, 4078-4081——A certain amount of school attendance should be required on the part of all miners' children under a certain age, 4079, 4080

Reports, 1852-53—*continued.*

Blackwell, J. Kenyon. (Analysis of his Evidence)—*continued.*

——Evidence on the present system of Government inspection; the want of clearly defined responsibility is very objectionable, 4084-4130——How far witness agrees with Mr. Wood's suggestion, that the inspection should be immediately under the Board of Trade, and that in cases of difficulty the school of mines proposed by him should be consulted, 4085-4088——The responsibility should rest on the coal proprietors, and they should be subject to prosecution in the event of accidents occurring through their neglect of proper precautions, 4089-4092. 4098. 4121, 4122. 4127-4130.

Witness delivers in a list of explosions, involving altogether the loss of about 1,100 lives; with a few exceptions, these explosions arose from the use of naked lights, 4092-4094——The action of the inspectors should be limited to examinations, reports, and to offering opinions and suggestions for adoption by the coalowner, 4098, 4099. 4127-4130——The appointment of sub-inspectors from practical miners is not advisable, 4099. 4105, 4106——The inspectors should be men of great practical experience, and also of great weight of character; a little more practical knowledge would be an improvement to some of the present inspectors, 4099-4106——Grounds for the opinion that the present number of inspectors is not sufficient; from two to three times the number are required for a yearly inspection of all the mines, except some of the smaller ones, 4107-4115.

Remarks to the effect that no improvement in the management of mines can be traced to the Government inspection; the suggestions of the inspectors have not been generally adopted by the coalowners, 4116-4126——Extracts from reports on the subject of an explosion in 1846 in the Risca Black Vein Pit, by which thirty-five lives were lost; state of the ventilation, and suggestions for its improvement, 4131——Paper delivered in relative to an accident in March 1848 at Eaglesbush Colliery, whereby twenty persons were killed, 4131——Remarks on the subject of an explosion in August 1849 at Lletty Shenkin Colliery, near Aberdare; fifty-two lives were lost on this occasion, chiefly by suffocation from after-damp, 4131——Observations relative to explosions in December 1850, and May 1852, at Middle Dyffryn Colliery, Aberdare, by which respectively thirteen and sixty-five persons were killed; character of this mine, and of the ventilation adopted therein, &c., 4131.

Paper delivered in with respect to an accident at Washington Colliery, Durham, in August 1851, by which thirty-five lives were lost; five-sixths of these perished from after-damp, 4131——Remarks on the subject of an explosion in March 1847 at Ardsley Main Colliery, near Barnsley, by which seventy-three persons were killed; systems of working and of ventilation pursued; the after-damp was the great cause of death, 4131——Paper relative to explosions in February 1847, and January 1849, at Darley Main Colliery, near Barnsley, by which respectively six and seventy-five lives were lost; deficiency of the ventilation afforded, 4131——Reference to an accident in December 1851 at Warren Vale Colliery, Barnsley, by which fifty persons were killed, 4131——Remarks with respect to an explosion in January 1853 at Elscar Colliery, near Barnsley, whereby ten lives were lost; limited and insecure system of the ventilation, 4131.

Observations relative to accidents at Coppull Colliery, near Chorley, in November 1846 and May 1852, by which respectively eight and thirty-two persons were killed, 4131——Remarks on the subject of explosions at Ince Hall Colliery, in February 1850 and March 1853, by which respectively four and fifty lives were lost, 4131——Paper delivered in with respect to explosions in the South Staffordshire mines; these explosions arose from very imperfect ventilation, and the use of naked lights; the collieries were those of Rounds Green, Heathfield, Friary Field, and Whitehall, 4131.

Blasting. Regulations with respect to the use of gunpowder in blasting in coal mines, *Dickinson* 207——In all mines doubtfully safe, where lamps are employed, the use of gunpowder should be prohibited, *Swallow* 2908, 2909; *Wood* 3817, 3818.

See also *Gunpowder.*

Board of Trade. Suggestion that the inspection of mines, like the inspection of railways, become a separate department under the Board of Trade; beneficial working of such an arrangement, *Wood* 3864 *et seq.*——There should not be any intermediate authority between the Board of Trade and the staff of inspectors proposed by witness, *ib.* 3871——How far witness agrees with Mr. Wood's suggestion that the inspection should be immediately under the Board of Trade, and that in cases of difficulty the school of mines proposed by him should be consulted, *Blackwell* 4085-4088——The collieries should be placed under the superintendence of the Board of Trade, as also the appointment of inspectors, *Forster* 4728-4745.

Boiler Fires. Remarks as to the power to be attributed to the boiler fires in experiments made with the steam-jet, *Wood* 3374 *et seq.*——The power attributed by Mr. Wood to the heat of the boiler fires, and of the waste steam; this power is much less than is generally supposed, *Gurney* 4293-4298——Considerable effect which the boiler fires have upon the ventilation; witness can get as much air by the boiler fires as he originally obtained by the two furnaces at Seaton Delaval, *Forster* 4452-4470——The effect of the heat

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Boiler Fires—continued.

heat of the boiler fires producing the ventilation in Seaton Delaval Colliery was in the proportion of about 51¾ per cent., while the mechanical action of the jet was about 48¼ per cent., *Forster* 4513-4521.

See also *Seaton Delaval Colliery*, 1.

Bore Holes. Impossibility of bore-holes being sunk down from the surface into the goaves, so as to allow holes for the pent-up gas to escape, as recommended in the report of the Committee of 1852, *Dickinson* 1178-1185——Witness would not recommend bore-holes being made into the goaf, as it is more than probable they would become down-casts, *Jude* 1984-1990——Objection to putting down bore-holes, *Swallow* 2560-2562——The report of the Committee of 1852, as to putting bore-holes down on the goaves, is perfectly absurd; the effect would be to send air into the holes, and probably water also, instead of extracting the air out of them, *Wood* 3650-3654.

Boty's Lamp. See *Safety Lamps*, 5.

Boussu and St. Croix St. Clare Colliery (Belgium). Plan of this colliery, *Rep.* i. *App.* 141.

Boys. It is very material to the safety of the workmen working in various pits that the traps should be carefully attended to; this duty is generally performed by boys; witness is not prepared to recommend that boys should not be employed, *Dickinson* 1397-1401——Recommendation that a law should be enacted, prohibiting boys between ten and fourteen working more than eight hours per day; they at present work twelve hours, which is too much, *Jude* 2058-2074——Boys under fifteen years of age are not allowed to wind up and down the shafts; the age of such boys should not be under eighteen years, *Swallow* 2812, 2813.

See also *Employment of Children.* *Schools*, 1.

Brattices. Remarks with respect to the air being taken up the face of the work by a brattice; necessity of the brattice being carried sufficiently near the face to sweep it of all gas, *Mackworth* 653-659——There is always great danger in having a brattice in a shaft, *Jude* 1753——Deficiency of bratticing in the Newcastle and Durham coal mines; the only way of insuring the brattice being carried to the face of the work is by constant inspection, *ib.* 1795-1808——Necessity for the use of brattices, *Gray* 3078, 3079. 3135-3137. 3141.——*See* also *Anemometer.* *Natural Brattice.*

C.

Carbonic Acid Gas. See *Alloa Colliery.*

Carelessness of Miners. The carelessness on the part of the miners arises very much from recklessness of danger; they do not consider they are running any risk, *Dickinson* 376-382——It is desirable that specific enactments should be made against wilful neglect on the part of the men, *Jude* 2087-2092——How far sufficient enactments are at present provided against workmen who have been guilty of carelessness or recklessness whilst in the colliery, *Swallow* 2865-2876——The miners are fined or imprisoned for gross acts of carelessness in witness's district; no improvement of the law is required on this head, *Forster* 4806-4809.——*See* also *Punishment.* *Safety Lamps*, 3, 4.

Cayley, Edward. (Analysis of his Evidence.)—Has given attention to the question of ventilation of mines, 1521, 1522——Remarks relative to the fire in the mine at Alloa, Scotland, being extinguished by the injection of carbonic acid gas into the mine by means of the steam-jet after all other means had failed, 1523-1536. 1542——Loss of power in machine ventilation from the friction, 1537, 1538——There is no loss of power on the steam-jet from friction, 1539——Observations upon the subject of the steam-jet; grounds for the opinion that the steam-jet is a more powerful agent of ventilation than the furnace, 1539-1547——There is a limit to the furnace power of ventilation, 1545——The steam-jet, among the mechanical powers, is a more economical agent than any other apparatus, and less liable to danger from explosion, 1548——Remarks as to the explosion at Nitshill Colliery; there was no artificial means of ventilation, they trusted entirely to nature, 1549-1551.

Central Board. The central Government Board should consist of men well qualified to investigate existing evils, and to remedy the same; it would be an advantage if they had a practical knowledge of mining, *Tetlow* 3280-3286.

See also *Board of Trade.* *Closing of Mines.* *Sub-Inspectors.*

Choke-damp. See *After-damp.* *Refuge Stalls.*

Reports, 1852-53—*continued.*

Clanny Lamp. Remarks relative to the Clanny lamp; preference given by the workmen to it over the Davy lamp, *Jude* 1810-1817——Opinion that all lamps constructed on the principle of Dr. Clanny's are perfectly safe, and should be enforced in collieries; advantage of the flame being surrounded by glass, *Henderson* 2307-2310. 2314-2321. 2332——The Clanny lamp, which has a copper wire gauze, explodes more readily than the Davy lamp; objection to copper wire, *Wood* 3747-3749. 3754.

See also *Davy Lamp.* *Safety Lamps*, 2.

Cleaning of Lamps. See *Safety Lamps*, 4.

Closing of Mines. Remarks relative to the power of the inspectors in Belgium to stop the working of a mine in the event of its being improperly worked or being considered unsafe, *Dickinson*, 243-250; *Mackworth* 703-706——Where great danger evidently exists, and the proprietor refuses to resort to the most approved means for increasing the safety, the inspector should have the power to order the working of the mine to cease until such time as its condition be improved, or an arbitration shall have been held on the case, *Dickinson* 901-913——Objections to the inspectors having the power to stop the working of a mine considered to be in a dangerous state, *Mackworth* 1658-1663. 1676——After it had been decided upon an arbitration that a mine was unsafe, a magistrate should have the power of stopping the same, *ib.* 1659. 1676——One inspector should not have power to stop the working of a colliery; suggestion that there be a number of sub-inspectors appointed, and that he should take counsel with them as to the advisability of closing any mine, *Swallow* 2489, 2490——If the recommendations of the inspector were not attended to he should report the same to some Central Board in London, who should have power, after investigation, to close the mine, *Tetlow* 3252-3262——Objection to the inspector having power to stop a mine under any circumstances, *Forster* 4739.

Coed Talon Colliery. Evidence with respect to the Coed Talon Colliery, in Flintshire; it is very roughly managed; there have been more than the ordinary proportion of accidents, *Dickinson* 1346-1357.

Combe's Ventilator. Plan of Combe's ventilating fan, *Rep.* i. *App. Plan* (C.)

Consumption of Coal. Result of experiments at Hetton and Tyne Main Collieries in the relative consumption of coal by the steam-jet and furnace, *Rep.* iii. *App.* 159-161——Statement as to the consumption by furnaces, *ib.* 171.

See also *Furnace Ventilation*, 2. 5. *Hetton Colliery*, 2. *Mechanical Ventilators*, 2. *Seaton Delaval Colliery*, 1.

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Reference to the Report of the Committee of 1852 with regard to safety-lamps; how far witness agrees with that report, 1291, 1292——The use of the safety-lamp should be left to the discretion of the inspector, and to some extent to the manager, 1294-1296——Description of the safety-lamps in ordinary use in this country; the Davy lamp is most generally used; the Stephenson lamp is coming into general use, 1297-1299——Considering all the circumstances with reference to safety-lamps, witness is disposed to give the preference to the Davy lamp, 1300-1330——The inspector should at all times have power to order the use of safety-lamps in a fiery mine, 1331——The primary mode of rendering mines secure, is attention to the best mode of ventilation, 1332-1335.

Comparative merits of the several safety-lamps with regard to their illuminating power; the Eloin lamp gives the best light, but it is generally attended with the disadvantage of going out in a brisk current of air; preference to be given to Dr. Glover's lamp, 1336-1345——Evidence with respect to the Coed Talon Colliery, in Flintshire; it is a very roughly managed colliery; there have been more than the ordinary proportion of accidents, 1346-1357——Opinion in favour of the establishment of schools for the children of the workmen in collieries; such a system might be adopted without inflicting any great hardship on the colliery proprietors; manner in which the funds for such schools might be provided, 1358-1368.

Remarks

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Dickinson, Joseph (Analysis of his Evidence)—*continued.*

Remarks relative to the benefit societies and sick clubs existing among the workmen in coal mines; insufficiency of these societies to meet the case; it is very desirable that some provision should be made for the widows and orphans, which is not the case at present, 1369–1396——It is very material to the safety of the workmen working in various pits that the traps should be carefully attended to; this duty is generally performed by boys; witness is not prepared to recommend that boys should not be employed, 1397–1401——Remarks relative to the law which empowers the widows and orphans of colliers killed by accident to recover damages from the managers or owners of collieries; instance of an action having been brought at Wakefield, 1402–1404.

In some cases in Northumberland and Durham it is the practice to allow the widow of a miner killed by accident a free house and coal free for life, but witness cannot say that the practice is universal, 1405–1410——The expense of serious accidents by explosions is almost invariably very great on the owner, thus it is his interest to keep the mines in the best state possible, 1411–1413.

Dickinson, Mr. Witness disagrees with some portion of Mr. Dickinson's evidence as to the mode of ventilation adopted in Belgium, *Mackworth* 878, 879——Great satisfaction given to all parties in his district by Mr. Dickinson, the Government inspector; many evils have been remedied by his suggestions, *Swallow* 2506–2510; *Tetlow* 3243–3248.

Discipline. There are no mines in England which, as regards discipline among the workmen, surpass the Belgian mines, *Mackworth* 718–720——The discipline of the Belgian collieries is as nearly perfect as discipline can be, *ib.* 1512——Strict attention ought to be paid to the discipline of mines in all cases; the improved education of the colliers and overmen would be the means of insuring better discipline, *ib.* 1585, 1586.

See also *Distribution of Air.*

Distribution of Air. Great importance of the proper distribution of the air in the ventilation of mines; the safety of the mine depends upon the amount of ventilation, *Mackworth* 569–571; *Tetlow* 3297, 3298; *Forster* 4586–4592——The first essential of ventilation is to get a sufficient amount of air, and the next is to distribute it properly through the various workings of the mine, *Mackworth* 629, 630. 664–666——How far it would be possible, by any mechanical means, to measure the distribution of the air in a colliery, the splits being numerous, *ib.* 643–652——In every part of the mine there should be a certain minimum amount of air distributed for the safety and health of the miners, *ib.* 660–666——With regard to the distribution of air, the Belgium mines form a marked contrast to the mines in England; the perfect distribution of air and the thorough discipline and management prevents so large a proportion of accidents arising from explosions, *ib.* 712.

The distribution of air is generally very much neglected in English mines, *Mackworth* 713——Explanation as to the mode of distributing air in mines in Belgium; great advantages of the system, *ib.* 784–790——Great skill required for ensuring the proper distribution of air; both in the splitting and in the proper distribution of the air to the different parts of the working the system might be improved, *Dickinson* 1153–1159——The division of the air into a number of currents, and the enlargement of the air-courses, is the best method of taking a large quantity of air through a mine, *Mackworth* 1559——Evidence on the subject of a proper distribution of the air round all the workings in a mine; importance of the practice of air-splitting; recommendation of regulators rather than doors for the purpose of splitting the air and effecting its thorough circulation, *Wood* 3591–3634.

See also *Air-ways.* *Anemometer.* *Shafts.* *Splitting the Air.*

Don Alkali Works, South Shields. Observations as to the successful application of the steam-jet as a means of ventilation at the Don Alkali Works, South Shields, *Forster* 4477–4479.

Doors. When the traffic is carried across, the ventilation doors are used; frequency of these doors being blown away by an explosion, when the whole of the ventilation of the mine ceases; suggestions for remedying this evil, *Dickinson* 1174–1177——Precaution to be taken as a security in the event of explosions, provided regulators supersede the present doors; description of a regulator, *Wood* 3612–3627——Opinion that doing away with doors altogether would be attended with a great saving of life in cases of explosions, *Blackwell* 3966. 3969–3971——Impossibility of doing without doors to return the air in the ventilation of collieries, but the fewer doors that are used the better, *Forster* 4601–4604.——*See* also *Boys.* *Explosions.*

E.

Eagle's Bush Colliery. Paper delivered in relative to an accident in March 1848, at Eagle's Bush Colliery, whereby twenty persons were killed, *Blackwell* 4131.

See also *Tyne Main Colliery.*

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Education. Deficiency of the education provided for miner's children; average earnings of the parents, *Henderson* 2424-2443——It should be compulsory on the parents to contribute a certain sum weekly towards the education of their children, *Henderson* 2424-2443; *Swallow* 2898-2901——The colliers in the north of England are improving in intelligence and education; the good effects of this improvement are arguments in favour of a general system of education for the mining districts, *Wood* 3917-3921.

See also *Discipline. Miners. National Scientific Institutions. Schools.*

Eloin Lamp. Result of experiments on the Eloin lamp; construction of this lamp, *Wood* 3750, 3751. 3763-3766. 3772-3776——The Eloin lamp is of too delicate a construction; and is easily extinguished, *Forster* 4690-4692.——*See* also *Safety Lamps*, 2. 5.

Elscar Colliery. Remarks with respect to an explosion in January 1853, at Elscar Colliery, near Barnsley, whereby ten lives were lost; limited and insecure system of the ventilation, *Blackwell* 4131.

Employment of Children. The children of miners are now allowed by the Legislature to be employed in colleries when they attain the age of ten; in altering this law, witness would suggest that twelve rather than fourteen years of age be the limit; this alteration would be well received by the miners, *Tetlow* 3351, 3352. 3356-3360——It would be a very great hardship on the colliers if their children were not allowed to enter a mine till they were twelve or thirteen years old; for purposes of education they should, however, attend school for a certain number of hours weekly, *Wood* 3903-3905. 3908.

See also *Boys.*

Encroachments. With respect to encroachments being made, and coal extracted from adjoining properties, the offence by law is felony; instance of a colliery owner in Lancashire who was tried and sentenced to seven years' transportation, *Dickinson* 933-938——Particulars of the case of a colliery owner in Lancashire being tried for stealing coal by trespassing on adjoining properties; Mr. Dickinson's evidence is substantially correct, *Lancaster* 939-941.

Engineers. In Northumberland and Durham generally, and in the collieries under Mr. Wood, there is great freedom from accidents; this is attributable to the practical and scientific attainments of the engineers of that district, *Blackwell* 3966-3969. 3972, 3973.

Escape of Miners. See *Refuge Stalls.*

Escapes of Gas. It is of great importance that the power of ventilation should always be capable of being increased to meet any emergency, as an escape of gas from a blower, *Mackworth* 1577, 1578——Sudden escapes of accumulated gas frequently take place under the old system of stall-working; objections to this mode of working, and preference given to the long-work system, *Blackwell* 3946-3965.

Etienne, St., Colliery, France. Sketch of a method of working the great bed of coal at St. Etienne, in the south of France, *Dickinson* 83.——*See* also *Long-work System.*

Expansion of Air. Table of the expansion of air by heat, by Dr. Dalton, *Rep.* iii. *App.* 121——Similar table, by Magnus and Regnault, *ib.* 122.

Expense of Ventilation. Comparative first cost of establishment of various ventilating machines, at per horse power, *Rep.* i. *App.* 147——Comparative cost of working, at per horse power of useful effect, per annum, *ib.*

See also *Consumption of Coal. Cost of Ventilators. Furnace Ventilation*, 2. *Shafts.*

Experiments. With reference to the experiments to compare the furnace and steam-jet, they have been most carefully conducted; many of the results are so approximate as adequately, for ordinary purposes, to compare the two systems, *Mackworth* 1569-1572——Evidence as to experiments in ventilation made by witness with the furnace and the steam-jet; he has not made any comparison between the power of the two systems, *Gray* 2967-3000——Since the termination of the Committee of 1852 witness has tested the efficiency of the steam-jet; the experiments were made with the utmost fairness; neither Mr. Forster nor Mr. Goldsworthy Gurney were present, though invited to attend, *Wood* 3362-3364——Different systems of ventilation adopted by witness collectively and separately, in order to arrive at a correct estimate of the force of the steam-jet; size and number of the jets used; quantity of cubic feet of air per minute sent in circulation under the different systems, *ib.* 3365 *et seq.*——The experiments in ventilation recently made by witness do not militate against those tried by Mr. Elliott in 1849; witness's experiments go further, and show the result due to the mechanical force of the jet, *ib.* 3525-3529. 3562-3564——Some errors may have crept into the pamphlet containing an account of the experiments, but witness abides generally by the principles and conclusions therein stated, *ib.* 3522, 3523.

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Experiments—continued.

The experiments recently made by Mr. Nicholas Wood on the relative value of the furnace and the steam-jet were altogether incapable of testing the power of the latter; evidence in support of this assertion, *Gurney* 4141 *et seq.*——Mr. Wood's experiments were deficient in consequence of the displacement of the air by the steam-jet being supplied back again from above the jet, instead of from above the galleries of the mine, *ib.* 4143——The same error was made by Mr. Wood in his experiments in 1849, and it was then pointed out to him, *ib.*——The only fair experiment with the steam-jet was at Mr. Vivian's colliery in Wales; results of this experiment, *ib.* 4145–4151——How far witness can give any satisfactory explanation of his non-attendance at the experiments made by Mr. Wood on the relative powers of the furnace and the steam-jet, *ib.* 4306–4322——Witness expected an invitation to superintend the application of the jet, instead of which he merely received a printed circular, inviting him to be present on the occasion, *ib.* 4306–4322——Witness cannot account for Mr. Wood not having obtained such great results as witness in his experiments with the steam-jet, *Forster* 4576–4578.

See also *Consumption of Coal. Hetton Colliery*, 2. *Hilda, St., Colliery. Ince Hall Colliery. Killingworth Colliery. Seaton Delaval Colliery*, 2. *Steam Jet Ventilation. Tyne Main Colliery. Wood, Mr.*

Explosions. Diagram of every explosion which has taken place in the Lancashire, Cheshire, &c. district during 1852, showing the days on which the explosions took place, the variations of the barometer, taken three times a day, the variations of temperature, and the difference between the wet and dry bulb of a thermometer, and the daily fall of rain, *Dickinson* 117——Means possessed by the inspectors of ascertaining the cause in case of an explosion taking place in a mine, *Mackworth* 862–866——Reference to the serious losses inflicted on coalowners by the occurrence of explosions, *Wood* 3679–3681——In cases of explosions the stoppings and doors are generally blown away; they should be rendered much stronger and more secure, *Blackwell* 3961–3966——Reference to several collieries where explosions have occurred, which are mainly attributable to the insufficient separation of the air-currents from the doors, and from the want of proper stoppings, *ib.* 4056–4060. 4064, 4065——Paper delivered in by Mr. J. K. Blackwell, containing a list of the principal colliery explosions during seven years ending 1852, with the ascertained cause of ignition, *Rep.* iii. *App.* 177–179.

See also *After-damp. Artificial Ventilation. Fire-damp. Mechanical Ventilators*, 2. *Naked Lights. Owners of Collieries. Refuge Stalls. Staffordshire.*

F.

Fabrey's Ventilator. Comparison between Fabrey's and Struvè's ventilating machines; Fabrey's is the best ventilating machine in Belgium, *Mackworth* 1418, 1419——Abstract of five experiments thereon, by M. Jochams, *Rep.* i. *App.* 142——Plan of Fabrey's ventilator in wood, *ib. Plans* (D. and E).

See also *Mechanical Ventilators*, 1.

Falls of Roofs. See *Roofs.*

Fans. Comparative abstract of experiments on the economy of Fabrey's, Letoret's, Pasquet's, and Motte's fans, by M. Jochams, *Rep.* i. *App.* 141.

Fencing of Pits. Frequency of accidents in this country from the unprotected state of the mouth of the pits; it would be proper to enact a law to prevent pits being left in an exposed state, *Dickinson* 435. 942–947; *Mackworth* 684–689——Such a thing on the Continent is almost unknown, from the pits being fenced, *Dickinson* 435——Approval of the suggestion that every abandoned pit should be walled round, or properly secured, so as to prevent accidents, *Wood* 3689–3692.——*See* also *Prussia.*

Fife's Lamp. Observations on Dr. Fife's lamp; by having a talc surrounding the glass, one objection to the glass lamps is removed, *Jude* 1818–1821.

See also *Safety Lamps*, 2.

Fire-damp. Remarks relative to the proportion of atmospheric air required to be mixed with the fire-damp to render it explosive; when the air is too foul to be inflammable it is not capable of respiration, *Dickinson* 102–115——As a general rule, there is not a large quantity of fire-damp in any of the continental mines; they do not appear to yield as much fire-damp as the mines in the north of England, *Dickinson* 151–153; *Mackworth* 714–717. 1502——The Belgian mines are much more fiery and dangerous than the Prussian or the French mines, *Dickinson* 422——Paper delivered in by Mr. N. Wood, showing experiments made at St. Hilda Colliery, in resuming the ventilation, after its having been suspended to put in tubbing, the workings being entirely filled with fire-damp, *Rep.* iii. *App.* 171, 172.

See also *Goaves. Prussia. Temperature of Air. Ventilation.*

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Forster, Thomas Emerson. (Analysis of his Evidence.)—Viewer and manager of coal mines; extensively employed in the counties of Durham and Northumberland, 4343-4347——Evidence relative to the adoption of the steam-jet system at Seaton Delaval Colliery; the ventilation is much more perfect than it was during the time the mine was ventilated by furnaces; number of jets in use, and quantity of air obtained, 4348-4397——There has been no explosion or accident at Seaton Delaval since the establishment of the steam-jet; the colliery is in a very satisfactory state as regards ventilation, 4396, 4397——Comparison between the ventilation of Seaton Delaval Colliery with that of Mr. Wood's, at Killingworth, with the furnace; the quantity of air which is drawn through the latter is not so great as the quantity which is drawn through Seaton Delaval Colliery, 4398-4425.

Statement as to the arrangement of the steam-jets at the Seaton Delaval Colliery; they are placed at the bottom of the pit; witness does not consider that he has arrived at the true mode of applying the jets correctly, 4426-4441——Remarks relative to the water-gauge at Seaton Delaval Colliery, 4442-4445. 4489, 4490——Particulars as to experiments made at Seaton Delaval on 18 May, 4446-4451——Considerable effect which the boiler flues have upon the ventilation; witness can get as much air by the boiler fires as he originally obtained by the two furnaces at Seaton Delaval, 4452-4470——If the number of steam-jets at Seaton Delaval were increased, a much greater quantity of air might be obtained; and if the jets were placed in cylinders a greater power would be obtained; the use of cylinders is Mr. Gurney's suggestion, 4471-4477.

Observations as to the successful application of the steam-jet as a means of ventilation at the Don Alkali Works, South Shields, 4477-4479——Witness has not applied the steam-jet to any of the collieries under his management, except the Seaton Delaval, as they do not require more ventilation than they already have by the furnace, 4480-4483——Remarks relative to the Hetton Colliery; the Hetton Company are about to sink another pit in consequence of the ventilation being defective, 4484-4488. 4498, 4499——Statement as to the quantity of air passing through the Seaton Delaval Colliery per minute, 4491-4497——If the air is not carried to the extreme of the workings, the pit cannot be well ventilated, 4498.

[Second Examination.]—Great pains and labour bestowed by Mr. Wood on his experiments; whether the steam-jet or the furnace is the best mode of ventilation, all these experiments and inquiries will do a great deal of good, as tending to improve ventilation in collieries in the north of England, 4500-4503——Further remarks as to the quantity of air passing through the Seaton Delaval mine; a large portion of this passes directly from the down-cast shaft to feed the boiler fires, 4504-4509——Advantage of keeping the impure air of the mine away from the boiler fires for the use of the steam-jet, and from the furnaces, for the purpose of raising the ventilation by that means, 4508-4512.

The effect of the heat of the boiler fires producing the ventilation in Seaton Delaval Colliery was in the proportion of about 51¾ per cent., while the mechanical action of the jet was about 48¼ per cent., 4513-4521——If the steam-jets were placed at the top of the pit, and the cylinders were of too great a diameter, there is a liability of the return air passing down the inside of the tubes, which is called the pneumatic flower-pot; but with the jets placed at the bottom it is impossible, 4522-4533——Remarks as to the velocity of the air going up the pit at Seaton Delaval, 4534-4536——The way in which the steam-jets are placed makes a difference in the effect they will produce, 4538——There are certain discrepancies in Mr. Wood's tables, and account of his experiments, which require some explanation, but the discrepancies are not such as to invalidate the general truth of the tables, 4538-4556.

If the shaft of the Seaton Delaval mine was as large as the shaft in the Hetton Colliery the former would get a greatly increased quantity of air, 4557-4559——Circumstances under which witness abandoned the furnace in the Seaton Delaval Colliery, and adopted the steam-jet, 4560-4575——Witness cannot account for Mr. Wood not having obtained such great results as witness, in his experiments with the steam-jet, 4576-4578——Opinion that the steam-jet, as a means of ventilation, is more economical than the furnace, 4579-4581——Generally speaking, sufficient attention is not paid to the capacity and the size of the air-ways; they are far too small, 4583-4585——The distribution of the air is a very material point in producing perfect ventilation; object of splitting the air, 4586-4592.

Observations with respect to keeping the goaves clear of foul air; witness would not recommend them to be blocked up, 4593-4598——In all cases of explosions where large numbers of lives have been lost, the bulk of those deaths have resulted from the after-damp, 4599, 4600——Impossibility of doing without doors to return the air in the ventilation of collieries, but the fewer doors that are used the better, 4601-4604——Opinion that refuge stalls would not be of any advantage, as they would soon be filled with choke-damp, 4605-4611——Remarks relative to the accidents which occur from the falls of the roof; it is much better to employ people purposely to set the timbers than to allow the workmen to set them, 4612-4618.

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The head viewer incurs immense responsibility and is liable to great blame if he does not take every precaution to preserve the lives of his men, 4618–4620——Suggestion that covers should be placed on the tops of the cages used by the men in ascending and descending the pits, 4621–4640——But very few accidents occur in the north of England in winding persons up the shafts, 4621, 4622——The men should never be allowed to ascend or descend while coals are coming up, 4626–4628——Every care is taken to keep the machinery and ropes in good order in the north of England; it should be one of the duties of the inspectors to see that such is the case, 4641–4643. 4649——No persons should be employed as engineers in winding men up and down a pit, under eighteen years of age; in the north of England they are always upwards of twenty, 4644-4648.

Remarks relative to the use of Fourdrinier's safety apparatus on the cages for sending the men up and down the pits; however excellent the apparatus, it engenders carelessness as to the condition of the rope and machinery, 4649-4660——Witness uses nothing but wire rope in the collieries under his management, 4660——The safety-lamp is a great safeguard, but it ought not to be entrusted in the hands of men in an explosive mixture, 4661–4685——Witness would be very glad to have a better safety-lamp, if it could be constructed, 4663. 4690——The lamps should be kept locked, and the workmen never allowed to open them, 4686-4689——In the north of England the safety-lamps are placed under the superintendence of men appointed for that purpose, 4688.

The Eloin lamp is of too delicate a construction; and is easily extinguished, 4690–4692——Witness considers Dr. Glover's lamp is the best lamp, but it is rather too complicated, 4693, 4694——The Davy lamp is very simple, 4694——The present inspection does very little good; if there is to be an inspection at all, there ought to be more inspectors, and they should go down the pits oftener than at present, 4695–4722. 4749–4762——The inspectors should not be allowed to take any other work than the Government inspection, 4716–4719. 4749–4756——Objection to the appointment of sub-inspectors, as they and the overmen would be constantly quarrelling, 4723——The superintendence of mines by the sub-viewers, overmen and others is sufficient, and it is unnecessary to have any further superintendence, 4724——Necessity for the inspectors being men competent to judge of all the practical requisites of working a mine, 4725.

The inspectors should suggest alterations, as at present, but should not have power to enforce them, 4726, 4727——Suggestion that the collieries should be placed under the superintendence of the Board of Trade, as also the appointment of inspectors, 4728–4745——Objection to the inspector having power to stop a mine under any circumstances, 4739——Recommendation that a certain number of simple rules should be framed for the guidance of all persons entrusted with the superintendence of collieries; there would be no difficulty in framing such a set of rules, 4745–4748. 4763–4768——Witness always encourages his men to acquaint the inspector or manager with anything amiss in the mine; their complaints are always investigated, 4769–4778.

Witness has published a set of rules for the use of his collieries; there is no difficulty in enforcing them, 4779–4785——Class of men from which witness usually selects his overmen, 4786–4789——Remarks relative to the accident which occurred at Monkwearmouth in consequence of a shot of gunpowder being let off in a pit where there was a great accumulation of fire-damp; this was very imprudent, as they were working on the long-wall system, 4790–4796——It is very desirable that steps should be taken to establish mining schools in the several districts; the more education there is among the miners the better, 4797–4802——Great difficulty in obtaining proper persons to serve on coroners' juries; no one connected with a colliery where an accident occurs ought to be on a jury, 4803–4805.

The miners are fined or imprisoned for gross acts of carelessness in witness's district; no improvement of the law is required on this head, 4806–4809——In the event of accidents occurring from the neglect of the proprietors, the parties bring an action under Lord Campbell's Act, 4810, 4811——The proprietors of collieries would not object to be bound by rules and regulations laid down by practical men, but it would be a great hardship to be bound by compulsory powers put over them by incompetent persons, 4812–4817——Witness prefers the use of gunpowder smoke to the anemometer in measuring the quantity of air in a mine, 4818–4829——The anemometer cannot be considered a sufficient guide to an inspector who visits a mine once a month, of the quantity of air which has been passing through the pit during the time; the instrument might be tampered with, 4825–4828.

One of the great points in ventilation is to keep an eye on the increased size of the air-passages, 4830——Opinion that the miners would not object to a fixed amount being stopped from their earnings for the support of the colliery schools, provided they were allowed to interfere in the management, 4831–4842——Improved character of the miners as a body since witness first knew them; they pay much greater attention to the education of their children now than formerly, 4840–4842——In the event of any complaint being made to witness from the Miners' Association it would be fully investigated, and

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witness would protect any man making complaints, 4843-4848——Number of men and boys employed in the Seaton Delaval Colliery, 4849, 4850——Willingness of witness, in connexion with Mr. Wood, and other principal viewers, to consider and frame a code of rules which would be generally applicable to be enforced by law in the several collieries; necessity for the inspectors being present at these meetings, 4851-4854.

Fourdrinier's Apparatus. Objection to the use of Fourdinier's apparatus in the ascending and descending of pits, *Dickinson* 1230; *Henderson* 2361-2374; *Gray* 3113-3122; *Wood* 3706-3708——Reference to Fourdriner's cage and to that of Bell and Grant; the former is not at present employed at Monkwearmouth, *Henderson* 2361-2374——Remarks relative to the use of Fourdrinier's safety apparatus on the cages for sending the men up and down the pits; however excellent the apparatus, it engenders carelessness as to the condition of the rope and machinery, *Forster* 4649-4660.

France. Particulars as to the working of the thick coal in the south of France, *Dickinson* 28——Remarks relative to the coal mines in France; the mines are well worked, and the accidents are few, *ib.* 453-459.

See also *Accidents. Etienne, St., Colliery. Fire-damp. Inspection of Mines,* II. 2.

Furnace Ventilation:

1. *Generally.*
2. *Opinion in favour of the Furnace System of Ventilation.*
3. *How far there is any limit to Furnace Ventilation.*
4. *Remarks as to the Adoption of the System in Belgium.*
5. *Papers laid before the Committee.*

1. *Generally:*

The furnace operates by rarefaction; statement as to what is the test of that rarefaction, *Dickinson* 1085, 1086——The ventilation by rarefaction depends on the depth of the up-cast shaft, *Mackworth* 1463——Witness totally disagrees with the conclusion come to in the Report of the Committee of 1852 with respect to the existence of a furnace paradox, *ib.* 1575——Attempts made since the Report of 1852 to improve the furnace system of ventilation, and to increase its power, *Jude* 1739-1746——With respect to the furnace paradox, the more the air is rarefied by heat the greater must be the ventilation, *Gray* 3142, 3143——Opinion that four feet is the best length for a furnace, *Wood* 3450-3452——Remarks on the principles by which the furnace and steam-jet act; the former acts through the principle of rarefaction, the latter, if placed at the top of the pit, acts mechanically, and if placed at the bottom, by rarefaction, *ib.* 3504-3514. 3547 *et seq.*

2. *Opinion in favour of the Furnace System of Ventilation:*

The furnace, if unprotected, is a very dangerous means of producing ventilation; with the use of the dumb drift, and with proper precautions, it is perfectly safe, *Mackworth* 560-567. 600——Opinion that one eight-foot furnace properly constructed at the bottom of the up-cast shaft of the Seaton Delaval Colliery, would give more air than the whole of the steam powers now at work, and with a very much smaller consumption of fuel, *Dickinson* 1053——The furnace is much more economical than the steam-jet; the same quantity of coal would give more ventilation burned in a furnace than under a boiler, *ib.* 1128-1136——The furnace is not so peculiarly applicable to shallow pits as to deep ones, *ib.* 1136——Ordinarily speaking, witness recommends the adoption of a furnace in mines, principally on account of its convenience, and because it is in the majority of cases sufficiently effective in producing ventilation, *Mackworth* 1421——Under the majority of cases, the furnace is the most convenient and possibly the most economical, *ib.* 1576.

The ordinary working of the furnace should be very much below the power to which, in case of emergency, it might be worked, *Wood* 3397-3400——As a general rule, each furnace will consume three-quarters of a pound of coal per minute for each foot of width, the length of the furnace being about four feet, *ib.* 3447-3449——With reference to the working power of the coal, it may be taken as a general rule that 550,000 cubic feet of air are heated 1° with each pound, *ib.* 3449——The power of the furnace depends a good deal upon the depth of the shaft; in applying the furnace to deep mines, a higher water-gauge should be used than in small mines with less depth of shaft, *ib.* 3452, 3453.

3. *How far there is any limit to Furnace Ventilation:*

There is a limit to the furnace power of ventilation, *Cayley* 1545——All ventilation by mechanical power should be kept within certain limits; there should be a standard of velocity for the furnace and the steam-jet, and any increase of that velocity should be procured by enlarging the air-ways, having additional shafts, or splitting the air so as to diminish the resistance, *Wood* 3435-3441——Evidence on the subject of the furnace limit; remarks to the effect that the same resistance that would cause such limit would equally

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FURNACE VENTILATION—continued.

3. *How far there is any limit to Furnace Ventilation*—continued.

equally apply to the steam-jet or to any mechanical power, *Wood* 3718-3739——Remarks in support of the statement that there is a practical limit to the power of the furnace, *Gurney* 4156-4164. 4170. 4207.

4. *Remarks as to the Adoption of the System in Belgium:*

Particulars relative to the use of the furnace as a means of ventilation in Belgium; the furnace is inadmissible in mines which are called fire-damp mines, *Dickinson* 154-173——As a whole, the system of ventilation by furnace is very imperfectly carried out in Belgium, *ib.* 173, 174——The furnace mode of ventilation is not so well carried out in Belgium as it is in this country, *ib.* 223.

5. *Papers laid before the Committee:*

Description of furnaces used in ventilation; principles of action, &c., *Rep.* iii, *App.* 117, 118——Result of experiments made to test the efficiency of the furnace as a ventilating power, *ib.* 131 *et seq.*——Return by Mr. N. Wood, showing the consumption of coal by furnaces in several collieries, *ib.* 171.

See also *Belgium. Consumption of Coal. Experiments. Hetton Colliery*, 2. *Hilda, St., Colliery. Killingworth Colliery. Mechanical Ventilators*, 2. *Monkwearmouth Colliery. Naked Lights. Natural Brattice. Return Air. Seaton Delaval Colliery. Steam-jet Ventilation. Water-gauge. Wood, Mr.*

G.

Glass Lamps. See *Safety Lamps*, 2.

Glover's Lamp. Improvements made in the safety-lamp by Dr. Glover; this is a very safe and ingenious lamp, but on account of its weight and price it is not very likely to be introduced into mines, *Mackworth* 1592, 1593——With respect to Dr. Glover's lamp, it is objectionable on account of the difficulty of properly uniting the gauze so as to prevent the passage of the flame, *Henderson* 2308. 2311-2313——Opinion that Dr. Glover's lamp combines the two principles of giving the greatest quantity of light and the greatest safety, more than any other lamp; grounds for this opinion, *Wood* 3765-3771. 3777-3779. 3787, 3788——Witness considers Dr. Glover's lamp is the best lamp, but it is rather too complicated, *Forster* 4693, 4694.

See also *Davy Lamp. Safety Lamps*, 2.

Goaves. With regard to the ventilation of goaves, it is necessary either to ventilate them thoroughly, so as to clear out the whole of the fire damp, or not to do it at all; an imperfectly ventilated goaf is a most dangerous thing in a colliery, *Dickinson* 98. 101——With a properly ventilated colliery the ventilation ought always to be such as to sweep away any discharge of fire-damp from the goaves, *ib.* 121——It is very desirable that the goaf should be thoroughly cleared of foul air, *Dickinson* 1151; *Jude* 1725-1729. 1783-1792; *Swallow* 2624-2626; *Forster* 4593——Suggestions as to the best means of ventilating the goaves and of driving out the gaseous air, *Swallow* 2624-2646; *Wood* 3640-3655; *Forster* 4593-4598——Recommendation of the practice adopted in a colliery of Messrs. Lees, Jones and Booth, for the purpose of clearing the goaves of the noxious air, *Tetlow* 3312-3315.

It is much better to expel the foul air from the goaves than to attempt to wall it in, *Tetlow* 3317, 3318; *Forster* 4593-4598——A good current of air should at all times circulate close up to the face of the goaves, *Tetlow* 3319——A partial ventilation of the goaves is extremely dangerous, and is much worse than no ventilation at all, *Wood* 3640-3655——Recommendation of certain means for the insulation of goaves so as to carry off any exudation of fire-damp, thereby rendering them perfectly safe, *ib.* 3642-3649.——*See* also *Bore-holes. Naked Lights.*

Gobbing. With respect to gobbing, there is generally sufficient rubbish in the mines to fill the gob; in thick mines, when there is not sufficient rubbish, it is brought down the pits from the surface, *Dickinson* 26-28——Observations relative to gobbing; the gob walls are not ordinarily sufficient to carry the air along the face of work; it is very commonly the rule not to carry forward the gob until there is some indication of fire-damp in the lamp, *Mackworth* 797-813——Witness would not recommend gobbing as one of the rules for the management of mines, *ib.* 816, 817.

See also *Air-ways. Long-work System.*

Grand Bac Pit, Liege. Remarks relative to the ventilation of the Grand Bac Pit, near Liege, where the air is split ten times, each passing one face of work, *Mackworth* 1415.

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Gray, William. (Analysis of his Evidence.)—Resides at Margam, 2937——Has been engaged in collieries all his life in different capacities; is now employed by Mr. Vivian; extent of the workings superintended by witness, 2938-2966——Evidence as to experiments in ventilation made by witness with the furnace and the steam-jet; he has not made any comparison between the power of the two systems, 2967-3000——Circumstances under which witness has made use of the steam-jet; result of experiments at the Morfa Colliery; objection to the steam-jet apparatus as being very liable to get out of order, 2971-2991——It is very necessary to pay great attention to the size of the air-ways, for the purposes of ventilation, and to distribute the air by a system of splitting in sufficient quantities throughout the pit, 3001-3008.

Reference to an accident which occurred about three years ago in a colliery under the superintendence of witness; seven men were killed by an explosion of damp; the cause of the explosion was attributed to the use of open lights, 3009-3016——Since that period safety-lamps have been used, and not a single accident has occurred in the same mine, 3017-3022. 3074-3076——The common Davy lamp is the one used by witness; preference given to it over the Clanny lamp; security of Dr. Glover's lamp, 3024-3033——Remarks generally on the precautions taken in witness's pit in the use of safety-lamps; they are properly cleaned and repaired, and a heavy fine is imposed on any one who unlocks them or takes the top off without authority, 3034-3055. 3068-3077——Suggestion that it should be made an offence against the law for a workman to take off the top of his lamp, 3043-3055.

Comparison of expense between the use of the Davy lamp and of candles, showing that it is fifty per cent. cheaper to work with the former, 3056-3067——Necessity for the use of brattices; there is no such thing as a natural brattice, 3078, 3079. 3135-3137. 3141——Copy of the rules and regulations to be observed by the workmen employed at the Morfa Colliery; remarks thereon, 3080-3093——Evidence on the subject of winding the men up and down the shafts; there has been only one accident during this process at the Morfa Colliery; the loss of life on this point is entirely attributable to carelessness, 3092-3112——Objections to the use of Fourdrinier's cage, or of White and Grant's apparatus; they are both subject to get out of order, 3113-3122.

In the Morfa Colliery the workmen prop the roofs; only one man has been killed from a fall of coal; proper attention is not generally paid to the timbering of the roof, 3123. 3127-3129——Approval of the principle of the employment of deputies in coal mines, 3124-3126——Opinion that the system of Government inspection works very well, 3130-3134——Temperature of different parts of the shaft in the Morfa Colliery, as taken by witness on a recent occasion, 3138-3140——With respect to the furnace paradox, the more the air is rarefied by heat the greater must be the ventilation, 3142, 3143——There cannot be too much air circulating through a coal mine, 3144-3149——Witness deducts weekly from the earnings of each man 1½*d.* for school, the same sum for the surgeon, and the same for the sick fund; the men do not object to this deduction, 3150-3153.

Great Hetton Colliery. See *Hetton Colliery.*

Gunpowder. General law concerning the employment of gunpowder in the operations of mining, especially in coal mines subject to fire-damp, *Rep.* i. *App.* 138-140.

See also *Blasting.*

Gurney, Goldsworthy. (Analysis of his Evidence.)—Inventor of the steam-jet as applied to locomotion and the ventilation of coal mines, 4132——The steam-jet was first introduced in 1816; witness never heard of its having been used prior to that time, 4133-4140——The experiments recently made by Mr. Nicholas Wood on the relative value of the furnace and the steam-jet were altogether incapable of testing the power of the latter; evidence in support of this assertion, 4141 *et seq.*——Mr. Wood's experiments were deficient, in consequence of the displacement of the air by the steam-jet being supplied back again from above the jet, instead of from above the galleries of the mine, 4143——The same error was made by Mr. Wood in his experiments in 1849, and it was then pointed out to him, 4143——When the drag of a mine is considerable, the steam-jet should be employed more powerfully in the area of the jet, and the area acted upon should be reduced, 4144. 4148-4154.

Definition of the principles of action of the steam-jet and the furnace, 4145-4196——The only fair experiment with the steam-jet was at Mr. Vivian's colliery in Wales; results of this experiment, 4145-4151——By varying inversely the areas of the jets and cylinders any amount of power may be produced, 4151-4154——The water-gauge can with difficulty be disturbed by the furnace to the extent of three inches, 4155, 4156——Remarks in support of the statement that there is a practical limit to the power of the furnace, 4156-4164. 4170. 4207——Explanation of the *vena contracta*, 4158, 4159——There is no limit to the power of the jet; by a proper application a disturbance of 300 or 400 inches of water-gauge may be produced experimentally; practically about eight inches of water-gauge has been produced in a coal shaft, 4165-4179.

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Gurney, Goldsworthy. (Analysis of his Evidence)—*continued.*

The steam-jet has an excess of power of ventilation beyond what is required for ordinary purposes, which under extraordinary circumstances could be suddenly brought into play, thereby diminishing or removing the fatalities consequent on explosions through the after-damp, 4180–4197——In deep pits the furnace may be as efficacious as the steam-jet, and more economical, but in shallow pits the jet has decidedly the advantage, 4198–4207——In some deep pits the steam-jet may be essentially necessary, as affording a power of ventilation without a limit, the limit of the furnace being at times extremely dangerous, 4206–4208.

There is not a single table drawn up by Mr. Wood in which there are not most extraordinary discrepancies, 4209, 4210——Remarks on Table No. 21 of Mr. Wood, in which he attributes a certain slight disturbance of the water-gauge, over and above that produced by the furnace, to the extra power of the steam-jet; evidence to the effect that there was no action of the steam-jet on this occasion, and that the increase attributed to the jet was due to the temperature, 4211–4254.

[Second Examination.] Further evidence in support of the assertion that Mr. Wood is in error in attributing a certain disturbance of the water-gauge to the power of the steam-jet; the jet was not properly applied, and there was no available power produced by it in the experiment in question at the Hetton Colliery, 4255–4272. 4286–4292——The application of the jets was so arranged by Mr. Wood that the air being driven up in front of the jets would naturally return again around them, or by the sides of the cylinders, and thereby supply the exhaustion below, forming what is termed the pneumatic flower pot, 4265–4272. 4286–4292——Objection to the experiments with the steam-jet at Tyne Main Colliery; cylinders were used, but were much too large in proportion to the size of the jets, 4273–4279——The size of the cylinder in relation to that of the jet must depend on the drag of the pit, &c.; a cylinder of five inches would, in most cases, be sufficiently large for a jet of one-eighth or three-sixteenths of an inch, 4280–4283. 4285.

The expense of the steam-jet, as regards the consumption of coal, is not much increased by enlarging the area of the jets and diminishing the size of the cylinders, 4284, 4285——Remarks as to the power attributed by Mr. Wood to the heat of the boiler fires and of the waste steam; this power is much less than is generally supposed, 4293–4298——A registering anemometer might be placed in every mine out of the reach of all parties disposed to tamper with it; mode by which this object should be attained, 4299–4305——How far witness can give any satisfactory explanation of his non-attendance at the experiments made by Mr. Wood on the relative powers of the furnace and the steam-jet, 4306–4322——Witness expected an invitation to superintend the application of the jet, instead of which he merely received a printed circular inviting him to be present on the occasion, 4306–4322.

Great advantage of the application of the steam-jet at the top of the down-cast shaft in the event of an explosion, 4323——Difference between high and low pressure steam with regard to the rate at which they severally move the jet, 4324——The action of the steam-jet is founded on the first law of motion, namely, that bodies in motion go on for ever unless they are stopped by something, 4325——The steam-jet has been introduced into almost every steamer on the Thames, and is being extended to the navy, 4326——Mention of several other useful applications of the steam-jet; as applied to the blast furnace of an iron forge the power has been got up to eight or ten inches of the water-gauge, 4327——Remarks on the subject of safety-lamps; exception taken by witness to Mr. Wood's statement that under certain conditions the Davy or other lamps would not explode; the Davy lamp, as shown by frequent experiments by scientific men, explodes at four feet rate of current, 4328–4342.

The danger of explosion arises from the retrograde motion, and witness has seen explosions of safety-lamps caused by the backward movement, 4331, 4332. 4337–4342——The Davy lamp is perfectly secure in a still atmosphere, and also in motion when the fire-damp has not reached the most inflammable point; it is unsafe when the fire-damp has arrived at the explosive mixture, 4336.

H.

Hainault, Belgium. Number of accidents which have occurred in the coal mines in Hainault in each year, 1849 to 1852, *Mackworth* 680.

Hall's Lamp. Approval of the principle of a lamp now being constructed by Mr. Hall, of Newcastle, *Wood* 3777.

Harton Colliery. See *Hilda St., Colliery.*

Haswell Colliery. The explosion at the Haswell Colliery in 1845 was occasioned by the insufficient separation of the ingoing from the outgoing air; seven-eighths of the loss of life occurred from the after-damp; report on the subject delivered in, *Blackwell* 4047–4052. 4131.

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Health of Miners. Bad ventilation is extremely injurious to the health of the men as well as uneconomical to the proprietors; miners are proverbially short-lived, *Mackworth* 1553-1557.——*See* also *Black Damp. Distribution of Air.*

Henderson, Robert. (Analysis of his Evidence.)—Practical miner at Monkwearmouth Colliery; has followed this occupation for twenty-eight years, 2270-2274. 2277-2279——Witness also carries on the business of a brass finisher, and has invented a safety-lamp for miners; explanation as to the construction of this lamp, showing how far it possesses any advantages over the Clanny and the Davy lamps, 2270. 2280-2307——Opinion that all lamps constructed on the principle of Dr. Clanny's are perfectly safe, and should be enforced in collieries; advantage of the flame being surrounded with glass, 2307-2310. 2314-2321. 2332——With respect to Dr. Glover's lamp, it is objectionable on account of the difficulty of properly uniting the gauze so as to prevent the passage of the flame, 2308. 2311-2313——Safety-lamps should at all times be secured by a lock and key; the workmen should not be provided with a key, and should never attempt to open the lock, 2322-2325.

Precautions necessary to be taken with respect to the cleaning and repairing of the lamps, 2326-2331——Remarks on the ventilation of the Monkwearmouth Colliery; it is carried on by means of a furnace, 2333-2341. 2375-2384——A sufficient amount of ventilation can be afforded to every mine, provided proper attention is paid to the return air-ways, 2333. 2342, 2343——With respect to the falling of roofs, the deputies are the most fit persons to see that sufficient timber is furnished to stand the roofs, 2344-2348——As regards the winding up and down the pit, Mr. Jude's suggestion that the men should pull the bell-rope is quite impracticable; opinion that the men are generally wound up too fast, 2349-2360——Reference to Fourdrinier's cage and to that of Bell & Grant; objections to their use; the former is not at present employed at Monkwearmouth, 2361-2374.

The system of long-wall work has been in practice about three years in Monkwearmouth colliery; witness prefers it to the ordinary board-and-wall system, 2375-2384——Evidence as to the best course to be pursued with respect to the appointment of inspectors and sub-inspectors; the sub-inspectors should be selected from practical miners; advantages to be derived from a proper system of sub-inspection, 2385-2405——Suggestions for altering the constitution of coroners' juries on accidents in coal mines; they should be empowered to inflict such penalties as are necessary for the relief of the distressed and to enforce better regulations, 2407-2423——Deficiency of the education provided for miners' children; average earnings of the parents; opinion that all miners, whether married or single, should contribute a weekly sum for the education of the children, 2424-2443——A national fund should be established for the support of the widows and orphans of those who meet with their deaths by accidents, and for the aged; this fund should be provided by contributions from the miners, and should be rendered imperative by Act of Parliament, 2444-2458.

Hetton Colliery:

1. *Generally.*
2. *Particulars as to Experiments made at the Colliery with the Steam-jet and Furnace.*

1. *Generally:*

Great improvements lately made in the ventilation of the Great Hetton Colliery, *Jude* 1745-1748——The Hetton Colliery is 900 feet in depth, and the workings extend over an area of upwards of 2,000 acres, *Wood* 3365, 3367——Remarks relative to the Colliery; the Hetton Company are about to sink another pit in consequence of the ventilation being defective, *Forster* 4484-4488. 4498, 4499——Synopsis of the ventilation of Hetton Colliery, with the respective distances which each current of air travels, and the quantity of air in each split, *Rep.* iii. *App.* 162-169——Return delivered by Mr. N. Wood, showing the ventilation of the Colliery, *ib.* 168, 169.

2. *Particulars as to Experiments made at the Colliery with the Steam-jet and Furnace:*

Evidence in detail with respect to experiments with the steam-jet and the furnace at the Hetton Colliery; result of these experiments; papers handed in in illustration thereof, *Wood* 3365 *et seq.*——The extent of the air-ways travelled under the experiments amounted in the aggregate to more than ninety-seven miles, *ib.* 3370. 3373. 3442——The power of the Hetton furnaces could be increased from 1·20 water-gauge up to 1·75; it is impracticable to attain a water-gauge of three inches, *ib.* 3394-3397——On 3 July 1853, witness made another experiment with the steam-jet; quantity of cubic feet of air per minute produced by the boiler fires and by thirty-seven jets during a trial of twelve hours, *ib.* 3400-3413——Result of counter experiments with the furnace alone as against the steam-jet, *ib.* 3414-3417.

Comparison of the consumption of coals in the use of the furnace and of the steam-jet; the balance is rather against the former, as the quantity of air with the furnace is greater than

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HETTON COLLIERY—continued.

2. *Particulars as to Experiments made at the Colliery, &c.*—continued.

than with the steam-jet, *Wood* 3414-3416——There are three furnaces in use at the Hetton Colliery; one of these, which is nine feet wide, produced about the same velocity of the current and the same quantity of air as the steam-jet, *ib.* 3414-3416——Remarks as to the resistance of the drag of the air round the workings, and of the resistance in the shaft and over the furnace, *ib.* 3418-3422. 3428-3434——Corroboration of witness's statements as to the consumption of coals by an account of the practical working of the furnace at seventeen collieries in the neighbourhood of Newcastle, being the result of an inquiry by Professor Phillips, *ib.* 3444-3452——Experiments made at the Hetton Colliery to determine the actual as well as the relative powers of the furnace and the steam-jet, *Rep.* iii. *App.* 131-138. 145, 146. 150 *et seq.*

See also *Shafts.* *Steam-jet Ventilation*, 2.

Hilda, St., Colliery. Reference to experiments made by witness at the St. Hilda and Harton Pits, South Shields; the result shows that the power of the steam-jet is inferior to that of the furnace, *Wood* 3534-3546. 3578-3581——The application of the jet to St. Hilda Colliery was in the first instance judicious and useful, but it was insufficient to clear the pit entirely of bad air, and the furnace was resorted to, *ib.* 3537-3546——Result of experiments made at St. Hilda Colliery in resuming the ventilation after it had been suspended to put in tubbing, the workings being entirely filled with fire-damp, *Rep.* iii. *App.* 171, 172.——*See* also *Fire-damp.*

I.

Impure Air. Advantage of keeping the impure air of the mine away from the boiler fires for the use of the steam-jet, and from the furnaces, for the purpose of raising the ventilation by that means, *Forster* 4508-4512.

Ince Hall Colliery. Evidence generally as to a series of experiments made by Mr. Wynne and witness at the Ince Hall Colliery, Wigan, with respect to the ventilation by steam-jet; detail of the results of those experiments, *Dickinson* 1108-1125——Mr. Darlington accompanied witness when making the experiments, and made no objection to the mode adopted in carrying them out, *ib.* 1137-1139——Remarks on the subject of explosions at Ince Hall Colliery in February 1850 and March 1853, by which respectively four and fifty lives were lost, *Blackwell* 4131.

See also *Pemberton Pits, Wigan.* *Seaton Delaval Colliery.*

Indications of Danger. See *Approach of Danger.* *Barometer.* *Water-gauge.*

INSPECTION OF MINES:

I. *Evidence relative to the Inspection of Collieries in England:*
1. Generally.
2. Remarks as to the Insufficiency of the present Number of Inspectors; Suggestions on the subject.
3. Observations relative to the Duties and Powers of the Inspectors.

II. *Particulars as to the Inspection of Mines on the Continent:*
1. Belgium.
2. France.
3. Prussia.

I. *Evidence relative to the Inspection of Collieries in England:*

1. Generally.

The mines in this country do not require the number of inspectors which the continental governments have for their mines, *Dickinson* 439——Manner in which the occasional inspection of mines would essentially operate to reduce the number of accidents, *Mackworth* 830, 835, 838——Witness never heard any complaints of the insufficiency of the present inspection, *Dickinson* 893——Remarks generally on the subject of the inspection; the appointment of inspectors has been very beneficial in the prevention of accidents, *Swallow* 2475-2520, 2525, 2526. 2531, 2532. 2764-2773. 2928-2936——Some collieries should be visited by the inspectors within certain periods, but this rule should only apply in peculiar cases, *ib.* 2517-2520.

Opinion that the system of Government inspection works very well, *Gray* 3130-3134——Consideration of the present system of inspection; evidence showing that it is not conducted upon a proper basis; suggestions for its improvement, *Wood* 3829-3900——

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INSPECTION OF MINES—continued.

I. *Evidence relative to the Inspection of Collieries in England.*—1. Generally—*contd.*

The inspectors are generally competent to undertake the duties of their office, *Wood* 3864——Remarks to the effect that no improvement in the management of mines can be traced to the Government inspection; the suggestions of the inspectors have not been generally adopted by the coalowners, *Blackwell* 4116-4126——The superintendence of mines by the sub-viewers, overmen, and others, is sufficient, and it is unnecessary to have any further superintendence, *Forster* 4724.

2. Remarks as to the Insufficiency of the present Number of Inspectors; Suggestions on the subject.

It would occupy witness four or five years to visit all the mines in his district; he is well acquainted with the most dangerous collieries, and to those he most directs his attention, *Mackworth* 601-607——Impossibilty of the inspectors visiting the whole of the mines included in their districts oftener than once in four or five years; objections to diminishing the area of the districts, *ib.* 731, 733. 742-745. 1608-1621. 1625-1629——Opinion that a very moderate increase in the present number of inspectors would be quite sufficient for all the requirements of this country, *Dickinson* 894, 896——Suggestion for the appointment of an additional number of inspectors, *Mackworth* 1608-1621. 1625-1629——As one means of increasing the security of mines, there should be increased superintendence on the part of Government; increased inspection would so increase energy in the viewers and persons connected with the ventilation, as would ensure its effectiveness, *Jude* 1904-1910.

The inspection is far from satisfactory; the number of inspectors is not sufficient, and their powers are much too limited, *Jude* 1947-1957; *Swallow* 2483-2490——Insufficiency of the number of the Government inspectors, *Wood* 3861. 3899——Grounds for the opinion that the present number of inspectors is not sufficient; from two to three times the number are required for a yearly inspection of the mines, *Blackwell* 4107-4115——The present inspection does very little good; if there is to be an inspection at all, there ought to be more inspectors, and they should go down the pits oftener than at present, *Forster* 4695-4722. 4749-4762.

3. Observations relative to the Duties and Powers of the Inspectors:

Instead of increasing the number of inspectors, the better plan would be to increase their power, *Dickinson* 896-902——It should be the duty of the inspector to see that proper engine tenters are employed, that the shafts are properly walled, and that there is a sufficiency of timber for the purpose of propping the roofs, *Swallow* 2796. 2814-2823——Remarks upon the system of Government inspection; it has been very beneficial in its operation, but does not go far enough; suggestion for the appointment of a certain number of sub-inspectors, who should be practical miners, with ample power of reporting on all matters that require improvement, *Tetlow* 3238-3256. 3263-3295. 3332-3339.——The suggestions of the inspectors to the coalowners are in effect orders, and are not always duly weighed before being issued, *Wood* 3862, 3863——Evidence on the present system of inspection; the want of clearly defined responsibility is very objectionable, *Blackwell* 4084-4130.

The action of the inspection should be limited to examinations, reports, and to offering opinions and suggestions for adoption by the coalowner, *Blackwell* 4098, 4099. 4127-4130——The inspectors should be men of great practical experience, and also of great weight of character; a little more practical knowledge would be an improvement to some of the present inspectors, *ib.* 4099-4106——The inspectors should not be allowed to take any other work than the Government inspection, *Forster* 4716-4719. 4749 4756——Necessity for the inspectors being men competent to judge of all the practical requisites of working a mine, *ib.* 4725——The inspectors should suggest alterations, as at present, but should not have power to enforce them, *ib.* 4726, 4727

II. *Particulars as to the Inspection of Mines on the Continent:*

1. Belgium:

Evidence generally with respect to the system of inspection of mines and the number of inspectors in Belgium, *Dickinson* 181-200. 224-292; *Mackworth* 691-711——The control which is exercised by the Government inspectors is much more stringent than that which is exercised by the inspectors in this country; their powers are more extensive, *Dickinson* 181-200——The visits of the inspectors are more frequent than they are in this country; this is owing to the great difference in the extent of the districts, *ib.* 259-268——Particulars as to the books kept at each mine in Belgium for the inspecting engineers to write remarks in on their visits, *ib.* 279, 280——Class of men who are charged with the daily inspection of the mines; they are similar to the overmen in this country, are employed by the proprietors of the mines, and are not paid by Government,

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INSPECTION OF MINES—continued.

II. *Particulars as to Inspection of Mines on the Continent.*—1. Belgium—*continued.*

ment, *Dickinson* 285–292——Remarks relative to the frequent supervision of the mines in Belgium; number of supervisors appointed whose duty it is to inspect the state of the lamps, the conduct of the men, and the state of the mine, *Mackworth* 720—The sub-engineers or aspirants employed in the inspection of mines are the most highly-educated men in the country; strict examinations which they undergo previous to becoming aspirants, *ib.* 721–726——Remarks upon the system of Government inspection in Belgium; opinion that its introduction into this country is very desirable, *Wood* 3866 3870. 3875.

2. France:

Particulars as to the system of inspection in France; the Government take five per cent. of the profits, *Dickinson* 462, 463.

3. Prussia:

Evidence with regard to the system of inspection in Prussia, *Dickinson* 446, 447.

See also *Accidents. Board of Trade. Brattices. Closing of Mines. Coroners' Inquests. Ironstone Mines. Machinery. Management of Collieries. Owners of Collieries. Plans of Collieries. Rules and Regulations. Safety Lamps*, 4. *Shafts. Sub-Inspectors. Supply of Air. Tests of Ventilation. Ventilation.*

Inspectors. See *Coroner's Inquests. Dickinson, Mr. Inspection of Mines*, I. *Safety Lamps*, 1. *Sub-Inspectors.*

Intimidation of Miners. Frequency of the miners being intimidated and prevented from giving information to the inspectors, from the fear of losing their employment; the men should be protected where they afford information, *Jude* 1871–1903.

Ironstone Mines Long work is peculiarly applicable to the ironstone mines, *Dickinson* 43——The present Act for the inspection of mines might be amended; suggestion that ironstone mines be included in the Act, *ib.* 897–900.

J.

Jarrow Colliery. Remarks on the explosion in 1845 at the Jarrow Colliery; a bratticed shaft, as used there, is extremely insecure; extracts from reports on this explosion handed in, *Blackwell* 4053–4056. 4131.

Jude, Martin. (Analysis of his Evidence.)—Innkeeper at Newcastle; has been thirty-four years engaged in working in collieries, 1687–1690——Is Secretary of the Miners' Association, 1691, 1692——The mines in Northumberland and Durham are not in a better condition as to ventilation than they were in 1849; 1693–1696——Nature of the grievances complained of by the miners; the workmen are anxious that there should be a sufficient quantity of air, the owners being responsible for the same, 1697–1704——Remarks relative to the operation of the steam-jet in the Seaton Delaval Colliery; the ventilation of that mine is very superior to any pit witness ever saw before, 1705–1718. 1793, 1794——In the event of regulations being issued to be observed in the mines, the pitmen would give information of any breach of the rules, 1719–1721.

The principal thing on which the safety of the pit depends is the size of the air-ways for the take-in, and the return air, 1722–1724——The goaves should be ventilated as far as possible, 1725–1729. 1783–1792——Remarks relative to the safety-lamps; the workmen prefer the Stephenson lamp to the Davy lamp, 1730–1736——The body of miners highly approve of the recommendations contained in the Report of the Committee of 1852; 1737, 1738——Attempts made since the Report of 1852 to improve the furnace system of ventilation, and to increase its power, 1739–1746——Great improvements lately made in the ventilation of the Great Hetton Colliery, 1745–1748——Insufficiency of the present number of shafts for the proper ventilation of mines; there should be two shafts sunk at the dip of the colliery, and one or two of equal area at the rise of the colliery, 1747–1782.

There is always great danger in having a brattice in a shaft, 1753——Deficiency of bratticing in the Newcastle and Durham coal mines; the only way of ensuring the brattice being carried to the face of the work is by constant inspection, 1795–1808——Remarks relative to the Clanny lamp; preference given by the workmen to this lamp over

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Jude, Martin. (Analysis of his Evidence)—continued.

the Davy lamp, 1810–1817——Observations on Dr. Fife's lamp; by having a talc surrounding the glass one objection to the glass lamps is removed, 1818–1821——The use of the safety-lamp should be rendered compulsory, 1822–1824——What the miners really want is sufficient ventilation whilst working; they should be enabled to complain to the inspector in the event of the supply of air being insufficient, 1825–1837——The workmen generally look upon the verdicts of coroners' juries as a farce, 1838, 1839——It should be imperative on the owner of a colliery to have one man always to clean the lamps and repair them, 1841——The safety-lamps should be locked, and the keys left with the overman; the miners should never be entrusted with the keys, 1842, 1843.

[Second Examination.]—The principal man or manager in a mine, in witness's part of the country, is called the head-viewer, and has an under-viewer for his assistant, 1844, 1845——Number of overmen and deputies employed in coal mines, 1846–1849——Statement as to the different classes of officers and men employed in the working and management, 1850–1863——What the miners principally want is sufficient ventilation; this can only be enforced by frequent inspection, 1864–1870——Frequency of the miners being intimidated and prevented from giving information to the inspector from the fear of losing their employment; the men should be protected where they afford information, 1871–1903.

As one means of increasing the security of mines, there should be increased superintendence on the part of Government; increased inspection would so infuse energy into the viewers and persons connected with the ventilation as would ensure its effectiveness, 1904–1910——The number of waste men has been considerably reduced since the introduction of the Davy lamp, 1911–1916——Opinion in favour of the appointment of sub-inspectors; this would give great satisfaction to the workmen; number of sub-inspectors that would be necessary; nature of their required qualifications, 1917–1946——The Act of 1850, which created the inspectors, has not given general satisfaction, from the inspection not being sufficiently extensive; the number of inspectors is not large enough, 1947–1957——Remarks relative to the Mining Association; meetings of the delegates, &c., 1958–1966.

Opinion that the working men would contribute towards the expense of the sub-inspectors if they had some little power in the nomination of them, 1967–1969——Observations with respect to the practicability of constructing refuge stalls, 1970–1983——Witness would not recommend bore-holes being made into the goaf, as it is more than probable they would become down-casts, 1984–1990——Suggestion for the formation of some tribunal for examining into the qualifications of the managers and officers of mines; a Board might be formed of some of the principal mining engineers in the country; this would be preferable to any Government Board, 1991–1997——Generally speaking, the officers in management of mines are extremely deficient in the qualifications that are requisite, 1998 *et seq.*——The principal viewers are generally a superior class of men in the north of England, 1999–2002.

Observations with respect to the qualifications of the under-viewers; many of this class are quite unfit for the office, 2002–2012——With regard to the overmen they are not generally a well qualified class of men; means by which they might be improved, 2013–2020——Evidence with respect to the schools established at the collieries in the north of England; deficiency in the means of education among the mining classes, 2021–2036——Opinion that if the establishment of a school was made compulsory on each colliery, a rate for their support being stopped from the earnings of the workmen, it would take very well with the miners, they having some control in the management themselves, 2037–2047——Remarks as to the nature of the instruction that should be afforded in the colliery schools; practical information with respect to mining might be given in evening schools, 2048–2057.

Recommendation that a law should be enacted prohibiting boys between ten and fourteen from working more than eight hours per day; at present they work twelve hours, which is too much, 2058–2074——Children should be compelled to attend the colliery schools; a certificate of a boy's having attended should be required before he was permitted to enter a mine, 2068, 2069——It is to the interest of the proprietor that the mine should be kept in an efficiently ventilated state, as the loss from an explosion is very great; witness attributes the neglected state of the mines in the north of England to false economy, 2075–2084——Workmen are disposed to work for less wages in mines which are notoriously well ventilated than in mines that are the contrary, 2085——Possibility of putting a fiery pit in such a condition that it should be absolutely safe, 2086. 2093–2099——It is desirable that specific enactments should be made against wilful neglect on the part of the men, 2087–2092.

The sub-inspectors should thoroughly inspect the mines, but should not interfere at all with the mode of working, so as in the least to remove the responsibility from the viewers or managers, 2100–2117——Frequency of accidents from the falls of the roof in mines; this might be avoided by more hands being employed as deputies to see that sufficient

pit

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pit props are placed, 2118–2133. 2204–2212——Evidence generally with respect to the accidents which occur to the men in ascending and descending the pits; they cannot be entirely avoided, but might be somewhat prevented by decreasing the speed at which the men are drawn up, 2134–2182——Remarks as to the employment of patent cages with guides on for ascending and descending the pits in the north of England; there has been less loss of life since these cages have been in use, 2140–2154.

Very few accidents have arisen from the slides being out of order in the north of England, 2183, 2184——Letter received by witness from the workmen in the Bedlington Colliery, dated 7 March 1853, complaining of the bad state of the mine; this letter witness forwarded to the inspector, who visited the colliery and suggested various improvements, which have since been carried out, 2184–2200——Provided proper regulations were made, and the inspector had the power to see that the pits, machinery, and ropes were kept in good order, it would almost entirely do away with the chance of accidents in winding up and down the people, 2201–2204——Objections to the roofs being propped by the miners, 2204–2212——The miners are very dissatisfied with the coroners' juries; they wish for a better class of jurymen; no person engaged in the working of a colliery should be on the jury, 2213–2217.

At present coroners can only find verdicts of accidental death, or manslaughter in cases of gross misconduct; they should have some intermediate power; some power to assess damages or impose penalties, 2218–2222——With respect to the schools the Mining Association are anxious that the Government should contribute 20*l.* per annum for every 100*l.* contributed by the coal hewers in the colliery, 2226–2230——And that the owners should allow all fines and forfeitures on the workmen's wages to go to such fund for the purpose of establishing reading-rooms, libraries, and getting lectures upon scientific subjects, 2227–2232——Evidence with respect to the experiments made at Seaton Delaval Colliery on the 15th June 1853, to prove whether the door that leads to the boiler fires being left open would lessen the current of air in the workings, when it was found to increase it, 2233–2269——Opinion that the Government inspector could not rely on the anemometer as a test for what quantity of air was passing through the mine, provided his visits were only once a month; a badly conducted overman could tamper with the anemometer and render it an insufficient test to be relied on, 2242, 2243.

K.

Killingworth Colliery. Result of experiments at Killingworth Colliery with the steam-jet and the furnace, showing the greater power of the latter, *Wood* 3469–3491. 3510–3514——Experiments made at Killingworth Colliery to determine the actual as well as the relative powers of the furnace and steam-jets, *Rep.* iii. *App.* 131, 132. 138–141. 146. 150 *et seq.*——*See* also *Density of Air. Safety Lamps,* 2. *Seaton Delaval Colliery.*

L.

Ladders. See *Ascent and Descent of Mines,* 1.

Lancashire and Cheshire Branch of the Miners' Association. See *Miners' Association.*

Lancashire Collieries. The ventilation in the small collieries of Lancashire is worse than in the large ones; there is a general complaint against the inefficient circulation of the air, *Tetlow* 3165–3167——Description of the Lancashire collieries, and mode of working pursued therein; sufficient attention is not paid to dividing the mine into districts, and to splitting the air, *Blackwell* 3974–3983.——*See* also *Explosions.*

Lancaster, Mr. See *Dickinson, Joseph.*

Large Collieries. The largest collieries are the best ventilated, because they are managed by men of a superior class, *Blackwell* 4027.

Legislation. Witness would not recommend the enforced adoption in the English mines of any system of ventilation in use in Belgium; the kind of ventilating power must be left entirely to the proprietor, *Mackworth* 1461——It should be enacted that ventilation should be produced and conducted by perfectly safe and efficient means, *ib.* 1520——It is not desirable for the Legislature to enforce any particular system of ventilation; it must be left to the coalowners, with a proviso that there shall be a sufficient quantity of air passing through the mine, *ib.* 1576——The miners consider that there should be no further delay in legislating for a better system of ventilation, and expect to derive many benefits if the Report of the Committee of 1852 is carried into effect, *Swallow* 2911–2927——All that is wanted for the purpose of improving the present state of collieries, and securing greater safety, is a thorough determination on the part of Government to effect that object, *Tetlow* 3290.

Lemielle's Ventilator. Plan of Lemielle's feathering fan, *Rep.* i. *App. Plan* (D).

Lesoinne's Ventilator. Plan of Lesoinne's windmill ventilator, *Rep.* i. *App. Plan* (B).

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Letoret's Ventilator. Plan of Letoret's ventilator fan, *Rep.* i. *App. Plan* (A).

Lighting of Mines. General law concerning the ventilation and lighting of mines, *Rep.* i. *App.* 138–140.——*See* also *Safety Lamps.*

Lletty Shenkin Colliery. Remarks on the subject of an explosion in August 1849, at Letty Shenkin Colliery, near Aberdare; fifty-two lives were lost on this occasion, chiefly by suffocation from after-damp, *Blackwell* 4131.

Long-work System. The common system of working wines in Belgium is long work; remarks on that system, *Dickinson* 9 *et seq.*——Explanation of the system of long work, as practised in this country; difficulty in carrying on ventilation under the system, unless the gob is packed very tightly, and the sides of it clayed to prevent leakage, *ib.* 10–15——The thick coal of Staffordshire is worked by long work, which is a great improvement on the old system, *ib.* 28. 39——There is no system so efficacious as long work; all the coal is obtained by it, and the ventilation is much simplified, *ib.* 28–30——Statement as to the counties in which long work has been adopted; it is as well done in the districts in England as it is in Belgium, *ib.* 31–33. 38–42——Nature of the danger attending the beginning of the system of long work; the first weight is usually a dangerous weight; the men usually abandon that portion of the work until the subsidence of the roof takes place, *ib.* 34–37.

Opinion that long work is the cheapest and best system, and is applicable to thick and thin seams of coal, *Dickinson* 44–48——Possibility of applying the system of long work to mines which are already established, though in some cases it would entail great expense, *ib.* 49–51——Evidence showing the advantages of the long-work system for ventilation over the pillar-and-stall working; much greater force must be applied to secure good ventilation on the stall system as compared with the long-work system, *ib.* 52–75——Opinion as to the best mode of commencing the long-work system; the best plan is to work the lower part first, taking care to pack the gob very tight with rubbish, *ib.* 89–100——The long-work system of working thick coal at St. Etienne, France, might be introduced into South Staffordshire, *ib.* 460, 461. 470, 471——The system of long work, as carried out at St. Etienne, is not universally adopted in France; it would be advantageous if it was adopted in all places where thick coal is worked, *ib.* 464–473.

See also *Escapes of Gas. Ironstone Mines. Pillar-and-Stall System. Roofs. South Wales. Working of Mines.*

M.

Machinery. It is the duty of the inspectors to see that the machinery and apparatus connected with the pit are in proper order; the managers generally attend to their representations, *Dickinson* 1231–1234——Provided proper regulations were made, and the inspectors had the power to see that the pits, machinery, and ropes were kept in good order, it would almost entirely do away with the chance of accidents in winding the people up and down, *Jude* 2201–2204——The ropes used in lowering the men are frequently very defective from wear, *Tetlow* 3216–3218——Every care is taken to keep the machinery and ropes in good order in the north of England; it should be one of the duties of the inspectors to see that such is the case, *Forster* 4641–4643. 4649.

See also *Ascent and Descent of Mines. Mechanical Ventilators.*

Mackworth, Herbert Francis. (Analysis of his Evidence.)—Government Inspector of Mines for the South Western district, 474-477——Statement of the accidents which occurred in the coal mines of Great Britain in 1851 and 1852; observations thereon, 480, 481——Considerable decrease in the number of accidents in shafts in 1852; this may be attributed to the Government inspection, 480–511——On witness discovering any defects in the shafts of any of the mines under his inspection, he has suggested alterations and improvements to the managers, which have invariably been carried out, 489–513——Particulars relative to the explosion which occurred at the Middle Dyffryn Colliery, Aberdare, on 10 May 1852, from the improper use of the furnace for the ventilation of the mine, 517–555. 591–599.

Reference to Mr. Kenyon Blackwell's report on the state of that colliery, in which he recommended that naked lights should not be used in the mine on account of the imperfect state of the ventilation; difference of opinion existing as to whether a furnace is a naked light or not, 533–555——Remarks relative to the barometer as a means of indicating danger; the fall of the barometer would indicate the necessity for greater vigilance on the part of the persons having charge of the ventilation, 544–546. 568——Witness considers a furnace to be a naked light, 555–559——The furnace if unprotected is a very dangerous means of producing ventilation; with the use of the dumb drift, and with proper precautions, it is perfectly safe, 560–567, 600——Great importance of the proper distribution of the air in the ventilation of mines; the safety of the mine depends upon the amount of ventilation, 569–571.

Mr.

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Mackworth, Herbert Francis. (Analysis of his Evidence)—*continued.*

Mr. Blackwell, in his official report on the Middle Dyffryn Colliery, condemned the use of brattices and all naked lights; these recommendations were not attended to up to the time of the accident in May; since that accident those suggestions have been adopted, and the system in operation at the mine altered, 572-590——Opinion that the adoption of Mr. Blackwell's suggestions would probably have been attended with a great saving of life, if not an entire avoidance of the accident, 573, 577——It would occupy witness four or five years to visit all the mines in his district; witness is well acquainted with the most dangerous collieries, and to those he most directs his attention, 601-607——Witness does not consider that the self-registering anemometer could be depended on as indicating the state of the ventilation, because the air-ways may be altered from time to time so as to affect very materially the results indicated by it, 608-628. 643-652.

The first essential of ventilation is to get a sufficient amount of air, and the next is to distribute it properly through the various workings of the mine, 629, 630. 664-666——Frequency of the ventilation in particular mines in witness's district varying materially from the time of one visit to another, 631-634——Opinion that a perfect system of ventilation is the most important point with regard to the economical and proper working of a colliery, 635-637——Working miners generally know nothing whatever of the ventilation of a colliery, 638-642——How far it would be possible by any mechanical means to measure the distribution of the air in a colliery, the splits being numerous, 643-652——Remarks with respect to the air being taken up the face of the work by a brattice; necessity of the brattice being carried sufficiently near the face to sweep it of all gas, 653-659.

In every part of the mine there should be a certain minimum amount of air distributed for the safety and health of the miners, 660-666——No one instrument can test the distribution of the air; unless there is an anemometer in every working point, it cannot be ascertained that the air is thoroughly distributed, 667-676——Supposing the anemometer to be placed close to the end of the brattice, and the brattice was not lengthened as the heading advanced, the danger to the workmen would be increasing, whilst the indications of the instrument remained the same, 671-676——Manner in which witness tests the ventilation of mines on his visits of inspection, 677-679——Number of accidents which have occurred in the coal mines in Hainault in each year, 1849 to 1852; 680.

Comparative statement with respect to the number of men employed and the number of accidents in England, France, and Belgium, showing that the excess of deaths is considerably more in England than in the other countries, 681-683——Perfect system of management in Belgian mines, 683——Frequency of accidents in this country from the unprotected state of the mouth of the pits; it would be proper to enact a law to prevent pits being left in an exposed state, 684-689——It would be more destructive to life if the men were compelled to ascend and descend the pits by ladders in this country, 690——Remarks relative to the inspection of mines in Belgium; number of inspectors, their duties and powers, 691-711——The mines in Belgium belong to the Government; a royalty of two and a half per cent. on the profits is paid to the Government, 701. 710, 711.

Existence of a very excellent collection of rules for collieries, which are part of the laws of Belgium; rules for the workmen as well as for the masters, 703-708——Power of the inspectors to stop the mines in Belgium in the event of their being improperly worked, 703-706——The mines are better laid out in Belgium than they are in England, 712——With regard to the distribution of air, the Belgium mines form a marked contrast to the mines in England; the perfect distribution of air, and the thorough discipline and management, prevents so large a proportion of accidents arising from explosions, 712——The best managed collieries in England are often as well managed as collieries can be managed, 713——The distribution of air is generally very much neglected in English mines, 713——Comparison between the fiery mines of England and Belgium; the most fiery mines in England are more fiery than any coal mines in France, Belgium, or Prussia, 714-717.

The great principle of the ventilation of the mines in Belgium is that of ascensional ventilation, and throughout the Continent the greatest stress is laid on that point; by keeping all the air-courses in a mine gradually inclined upwards to the up-cast shaft, even a blower of gas which comes off finds its own way to the surface, 714——There are no mines in England which, as regards discipline among the workmen, surpass the Belgian mines, 718-720——Remarks relative to the frequent supervision of the mines in Belgium; number of supervisors appointed whose duty it is to inspect the state of the lamps, the conduct of the men, and the state of the mine, 720——The sub-engineers or aspirants employed in the inspection of mines in Belgium are the most highly educated men in the country; strict examinations which they undergo previous to becoming aspirants, 721-726——In ordinary managed mines in Belgium the system is infinitely superior to the system in England; this is attributable to the admirable code of regulations, 727-730.

Impossibility of the inspectors visiting the whole of the mines included in their districts at the present time oftener than once in four or five years; objections to

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diminishing the area of the districts, 731. 733. 742-745——Suggestion for the employment of sub-inspectors for the assistance of the inspectors, with powers nearly equal to those possessed by the present inspectors, 732-767. 874——Recommendation that a certain number of the most important regulations for the working of coal mines be passed into a law; a code of regulations could be adopted which might be applied universally throughout the country, 732. 740. 751-760. 773——The overmen employed in witness's district are, on the average, not very intelligent; great deficiency of information among them on many important points of safety, 768-772——In the code of regulations recommended by witness, he would not stipulate for any fixed quantity of air for the supply of a mine, 773, 774.

Although there is a great difference with respect to the fiery nature of mines, still regulations might be framed that would apply to all descriptions of mine, 775-781—— The use of locked safety-lamps should be compulsory in every colliery where there is any fire-damp at all; this is an important rule, and ought to be generally applied, 780. 834. 872, 873——Opinion that it is most desirable that artificial ventilation should be made compulsory in all collieries; more injury is caused to life and health by the want of ventilation in non-fiery mines than by all the accidents by explosions, 782, 783——In some cases a sufficient current of air is obtained by natural ventilation, but it is not to be relied on, 783——Explanation as to the mode of distributing air in mines in Belgium; great advantages of the system, 784-790——The distribution of air is very defective in the mines in England; how far it would be possible to introduce the ascensional ventilation as adopted in Belgium, 784-798.

Observations with respect to gobbing; the gob walls are not ordinarily sufficient to carry the air along the face of work; it is very commonly the rule not to carry forward the gob, until there is some indication of fire-damp in the lamp, 797-813—— The most convenient way is to work the coal first by stall and pillar, and then by long-wall work, 811——Witness would not recommend the Legislature of this country to enforce either the system of long-wall work or stall-and-pillar work; it would be impossible to say a proprietor should work his coal in this or that manner, 814, 815—— Witness would not recommend gobbing as one of the rules for the management of mines, 816, 817——Observations as to how far regulations might be adopted to enforce the requisite supply of air to mines so as to keep them in safe and proper working order; manner in which the sufficiency or insufficiency of the supply might be measured, 818-835.

Manner in which the occasional inspection of mines would essentially operate to reduce the number of accidents, 830. 835-838——It is a matter of great importance that before a man is allowed to undertake the management of a coal mine he should undergo an examination which should really test his ability, 836, 837——However great the discharge of fire-damp, there would be no difficulty in ventilating a mine with the ventilating powers at present possessed, 839-841——Observations as to the velocity of the currents of air that should be kept in motion in every working part of a colliery, 842-851——In all cases where the state of the atmosphere is such as to produce a halo round the candle the quantity of air should be doubled to prevent the danger of an explosion, 852-861——Means possessed by the inspectors of ascertaining the cause in case of an explosion taking place in a mine, 862-866.

Although a self-registering anemometer at the bottom of the up-cast and at the bottom of the down-cast would be no test of distribution, yet it would be a test of the amount of air entering the mine to be distributed, 867-871——The improved inspection of mines ought to be combined with a code of regulations, which the inspectors should see enforced, 875-877——Witness disagrees with some portion of Mr. Dickinson's evidence as to the mode of ventilation which is adopted in Belgium, 878, 879——With regard to mechanical ventilation, comparing the effective work with the consumption of coal, it will bear comparison with the best furnace ventilation in the north of England, 879.

[Second Examination.]—Correction of former evidence as to the accident in the Middle Dyffryn Colliery, and the number of deaths resulting from the explosion, 880-883—— Witness attributes that accident to the gas having come in contact with the furnace, 883-888.

[Third Examination.]—Explanation as to the general system of ventilating collieries in Belgium by means of mechanical power, 1414-1419——Remarks relative to the ventilation of the Grand Bac Pit, near Liege, where the air is split ten times, each passing one face of work, 1415——Comparison between Fabrey's and Struvè's ventilating machines; Fabrey's is the best ventilating machine in Belgium, 1418, 1419—— Mechanical ventilation is not practised in England, as there is an unfounded prejudice existing against it on account of its imagined liability to derangement, thereby possibly causing an explosion, 1420——Ordinarily speaking, witness recommends the adoption of a furnace in mines, principally on account of its convenience, and because it is, in the majority of cases, sufficiently effective in producing ventilation, 1421.

There are a number of ventilating powers employed in Belgium, which might be adopted with advantage in many of the English collieries which now require such powers

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powers to ventilate them; description of these ventilators, 1422-1438——Mechanical ventilators are applied in Belgium; the best are considered more certain, powerful, and economical than the furnace, 1426, 1427——Statement of certain experiments, with the different descriptions of ventilators which point out their peculiarities; relative value of these machines, 1424-1439——Details with respect to the Tyne Main Colliery ventilated by the furnace, forming an economical comparison between the ventilation of that and of the Eagle's Bush Colliery, where the first of Struve's ventilators was erected; the Tyne Main Colliery was lately experimented upon by Mr. N. Wood in the most careful manner, and it is from his data that witness gives the economical position of the ventilation of that colliery, 1439-1459.

Opinion that the ascending ventilation in use in Belgium should not be made altogether compulsory in collieries in England, 1460, 1461——Witness would not recommend the enforced adoption in the English mines of any system of ventilation in use in Belgium; the kind of ventilating power must be left entirely to the proprietor, 1461——The ventilation by rarefaction depends on the depth of the up-cast shaft, 1463——Particular conditions under which witness considers mechanical power would be preferable to furnaces in ventilating mines; generally speaking, the machine is preferable in proportion to the shallowness of the mine, and the amount of the drag, 1464-1469——How far the ventilation would be entirely stopped in the event of the ventilating machines getting out of order, 1470-1477——Remarks relative to the steam-jet; there would be an enormous loss of power if the steam-jet was applied directly to the air, 1478-1489.

Means by which the ventilators might be made so as to prevent their being destroyed in the event of an explosion occurring, 1490-1495——The use of a ventilator affords additional security for having a uniform current of air, 1495——Explanation as to the danger signals adapted to the ventilators in Belgium, which act through the medium of the water-gauge; these signals might be adapted to furnace ventilation, 1495-1501——The mines in Belgium are not so fiery as the most fiery mines in the north of England, 1502——The quantities of ventilation in the north of England in the larger collieries is three times as much as in the largest collieries in Belgium, 1503——With strictly ascensional ventilation much smaller quantities of air are necessary for safety, 1503.

The mechanical apparatus could be economically applied in England with efficiency; the machine may be worked more economically than the furnaces to produce the same amount of ventilation, 1504-1511——The discipline of the Belgian collieries is as nearly perfect as possible, 1512——Decrease in the number of deaths from accidents in mines in Belgium in the last fifteen years, 1513——Remarks relative to the experiments made on the steam-jet in Belgium, 1514-1519——It should be enacted that ventilation should be produced and conducted by perfectly safe and efficient means, 1520.

[Fourth Examination.]—Witness delivers in a description of the different ventilators in use in Belgium, 1552——Bad ventilation is extremely injurious to the health of the men, as well as uneconomical to the proprietors; miners are proverbially short-lived, 1553-1557——Natural ventilation is only applicable to mines under extremely favourable circumstances, 1558——The division of the air into a number of currents, and the enlargement of the air-courses, is the best method of taking a large quantity of air through a mine, 1559——Remarks as to the means by which ventilation is produced; it is not precisely correct to say that it is the height of the heated column of air which produces ventilation, 1560——Witness has invented an air-pressure gauge; description thereof, and mode in which applied, 1560, 1561.

Observations as to the most effective mode of measuring the effective ventilation of a colliery, 1562-1564——In estimating the efficiency of any system of ventilation it is important to take into account the amount of drag of the air; the neglect of this is at the bottom of the serious errors which have been made respecting the steam-jet, 1565-1572——With reference to the experiments to compare the furnace and steam-jet, they have been most carefully conducted; many of the results are so approximate as adequately, for ordinary purposes, to compare the two systems, 1569-1572——Witness does not agree with the Committee of 1852 as to the existence of a natural brattice, 1573, 1574——Witness totally disagrees with the conclusion come to in the Report of the Committee of 1852, with respect to the existence of a furnace paradox, 1575.

It is not desirable for the Legislature to enforce any particular system of ventilation; it must be left to the coalowners, with a proviso that there shall be a sufficient quantity of air passing through the mine, 1576——Under the majority of cases the furnace is the most convenient, and, possibly, the most economical, 1576——There are many cases in which mechanical ventilation is preferable, and can alone be effectual, 1576——It is of great importance that the power of ventilation should always be capable of being increased, to meet any emergency, as an escape of gas from a blower, 1577, 1578——Suggestions as to the capacity and size of the air-ways, and the best mode of carrying the air through the workings to the up-cast shaft, 1579-1581——Witness does not agree with the

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Mackworth, Herbert Francis. (Analysis of his Evidence)—continued.

Committee of 1852, as to the utility of refuge stalls; they could not be carried ou practically, 1582.

Crossings are very weak points in a mine; great care should be taken that they are made of sufficient strength, 1583, 1584——Strict attention ought to be paid to the discipline of mines in all cases; the improved education of the colliers and overmen would be the means of insuring better discipline, 1585, 1586——Recommendation for the establishment of schools for the colliers, 1587, 1588——Remarks as to the class of men acting as overmen in the mines; in some parts of the country they are of a much superior class than in other parts, 1587——Opinion in favour of the Davy lamp; witness never met with any well-substantiated case of an explosion having occurred from its use, 1589-1594——The glass safety lamp, by Mueseler, could be very advantageously introduced into the English collieries, 1589–1591.

The use of safety-lamps should be rendered compulsory in every fire-damp colliery, 1591——Improvements made in the safety-lamp by Dr. Glover; this is a very safe and ingenious lamp, but, on account of its weight and price, it is not very likely to be introduced into mines, 1592, 1593——Precautions which should be enforced to prevent accidents in ascending and descending mines, 1595——With regard to precautions against falls of roof, the system which is adopted in the north of England, of making the deputies set the props, tends to a considerable saving of life, and is almost universally employed on the Continent, 1595, 1596——It is essential that the Government inspector should have the power of enforcing a regulation that proper plans of all collieries should be kept, 1599–1601——The cleaning of the safety-lamps should not be left to the miners; there should always be a lamp man, 1602–1607. 1675.

Impossibility of witness satisfactorily inspecting his district, from its extent; suggestion for the appointment of an additional number of inspectors, 1608–1621. 1625–1629——Recommendation of a simple code of regulations, generally applicable, to be carried out for the whole of England, and enforced under penalties, 1610–1621. 1670–1676——Remarks relative to the managers of mines; the manager, in the majority of instances, is more or less in fault when an accident occurs, 1622–1624——Opinion that the manager should be considered responsible in the event of accident; examination to which managers should be subject, to test their qualification for the office, 1630–1653——Opinion that all collieries ought to be superintended by viewers, according to the system which has been found so effectual in the north of England, 1636. 1654–1657. 1677–1681.

Objections to the inspectors having the power to stop the working of a mine considered to be in a dangerous state, 1658–1663. 1676——After it had been decided, upon an arbitration, that a mine was unsafe, a magistrate should have the power of stopping the mine, 1659. 1676——The inspectors should not have the power of dismissing a manager; the appointment and dismissal should rest with the coalowner, 1664–1669——Witness would not recommend that the inspectors should interfere in the practical management of a mine, as it would take the responsibility from the coalowner and manager, which is not desirable, 1667–1669. 1672——All the safety-lamps should be kept locked, and the key kept by the man who has to clean the lamps daily; this is the law in Belgium, and is quite practicable, 1682–1686.

Magistrates. Magistrates, rather than the inspectors, or the Secretary of State, should be empowered to inflict penalties or fines upon the owners of collieries who neglect to perform their duties, *Swallow* 2863, 2864.——*See* also *Closing of Mines. Punishment.*

Management of Collieries. As a general rule, the best managed mines in England are better managed than the mines in Belgium or any of the continental mines, *Dickinson* 438——The best managed collieries in England are often as well managed as collieries can be managed, *Mackworth* 713——Witness would not recommend that the inspectors should interfere in the practical management of a mine, as it would take the responsibility from the coalowner and manager, which is not desirable, *ib.* 1667–1669. 1672——Statement of the different classes of officers and men employed in the working and management of coal mines, *Jude* 1850–1863——Opinion that the management of the Northumberland and Durham mines is the most perfect in the kingdom, *Wood* 3831. 3845, 3846——In those counties the number of accidents is diminishing, whereas in Yorkshire and the midland districts the reverse is the case; causes to which this is attributable, *ib.* 3846–3847——The responsibility of the management should rest exclusively with the managers themselves and not with the inspectors, *ib.* 3848.

See also *Belgium. Large Collieries. Overmen. Rules and Regulations. Working of Mines.*

Managers of Collieries. It is a matter of great importance that before a man is allowed to undertake the management of a coal mine he should undergo an examination which should really test his ability, *Mackworth* 836, 837——Remarks relative to the managers of mines; the manager, in the majority of instances, is more or less in fault when an accident occurs, *ib.* 1622–1624——The manager should be considered responsible in the event of accident; examination to which managers should be subject, to test their qualification for the office, *ib.* 1630–1653——The inspectors should not have the power of dismissing a manager; the appointment and dismissal should rest with the coalowner,

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Managers of Collieries—continued.

Mackworth 1664–1669——The only way in which accidents can be prevented is to bring about a superior knowledge and a greater capacity generally in the managers of the mines, *Wood* 3848, 3849——The managers of the South Wales mines are, as a class, very deficient in their attainments, *Blackwell* 4003.

See also *Management of Collieries. Miners. National Scientific Institutions. Overmen. Qualification of Officers. Safety Lamps*, 1. *Supply of Air. Viewers.*

Mechanical Ventilators:

1. *Particulars as to the Mechanical Apparatus adopted in the Ventilation of the Belgian Mines.*
2. *Advantages which would result from the introduction of the Belgian System into this Country.*
3. *Objections to the adoption of the Mechanical System of Ventilation.*

1 *Particulars as to the Mechanical Apparatus adopted in the Ventilation of the Belgian Mines:*

Explanation as to the general system of ventilating collieries in Belgium by means of mechanical power, *Dickinson* 131, 132; *Mackworth* 1414–1419——Description of the several mechanical appliances in use in Belgium, of which there are seven different varieties, namely, Fabrey's, Letoret's, Pasquet's, Lessoine's, Motte's, Lamielle's, and the piston, which is similar to M. Struvé's; of these Fabrey's is the best, *Dickinson* 131–141——List of experiments made in certain coal mines in Belgium with Fabrey's and Letoret's ventilating machines: cost of the ventilators, together with the steam-engines and erections, *ib.* 141——Statement of certain experiments with the different descriptions of ventilators which point out their peculiarities; relative value of these machines, *Mackworth* 1424–1439——Witness delivers in a description of the different ventilators in use in Belgium, *ib.* 1552——Result of experiments on ventilators used in Belgium, &c., *Rep.* i. *App.* 143–146.

2. *Advantages which would result from the introduction of the Belgian System into this Country:*

With regard to mechanical ventilation, comparing the effective work with the consumption of coal, it will bear comparison with the best furnace ventilation in the north of England, *Mackworth* 879——Mechanical ventilation is not practised in England, as there is an unfounded prejudice existing against it on account of its imagined liability to derangement, thereby possibly causing an explosion, *ib.* 1420——There are a number of ventilating powers employed in Belgium, which might be adopted with advantage in many of the English collieries which now require such powers to ventilate them; description of these ventilators, *ib.* 1422–1438——The best of the Belgian mechanical ventilators are considered more certain, powerful, and economical than the furnace, *ib.* 1426, 1427.

Particular conditions under which witness considers mechanical power would be preferable to furnaces in ventilating mines; generally speaking, the machine is preferable in proportion to the shallowness of the mine and the amount of the drag, *Mackworth* 1464–1469——How far the ventilation would be entirely stopped in the event of the ventilating machines getting out of order, *ib.* 1470–1477——Means by which the ventilators might be made so as to prevent their being destroyed in the event of an explosion occurring, *ib.* 1490–1495——The mechanical apparatus could be economically applied in England with efficiency; the machine may be worked more economically than the furnaces to produce the same amount of ventilation, *ib.* 1504–1511——There are many cases in which mechanical ventilation is preferable, and can alone be effectual, *ib.* 1576.

3. *Objections to the adoption of the Mechanical System of Ventilation:*

The mechanical system of ventilation in Belgium is not a satisfactory system or one that witness would recommend to be adopted in this country, *Dickinson* 148–150—— The longest level witness saw in Belgium was a mile from the shaft; this was considered adequately ventilated by mechanical power, but in this country a much larger supply of air would have been provided, *ib.* 216–218——Loss of power in machine ventilation from the friction, *Cayley* 1537, 1538.

See also *Belgium. Cost of Ventilators. Currents of Air. Distribution of Air. Expense of Ventilation. Fans. Furnace Ventilation. Steam-jet Ventilation.*

Middle Dyffryn Colliery, Aberdare. Particulars relative to the explosion which occurred at the Middle Dyffryn Colliery, Aberdare, on 10 May 1852, from the improper use of the furnace for the ventilation of the mine, *Mackworth* 517–555. 591–599——Reference to Mr. Kenyon Blackwell's report on the state of that colliery, in which he recommended that naked lights should not be used in the mine on account of the imperfect state of

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Middle Dyffryn Colliery, Aberdare—continued.

the ventilation; difference of opinion existing as to whether a furnace is a naked light or not, *Mackworth* 533-555——Mr. Blackwell in his report condemned the use of brattices and all naked lights; these recommendations were not attended to up to the time of the accident in May; since that accident those suggestions have been adopted and the system in operation at the mine altered, *ib.* 572-590——Opinion that the adoption of Mr. Blackwell's suggestions would probably have been attended with a great saving of life, if not an entire avoidance of the accident, *ib.* 573-577——Correction of former evidence as to the accident in the Middle Dyffryn Colliery, and the number of deaths resulting from the explosion, *ib.* 880-883——Witness attributes that accident to the gas having come in contact with the furnace, *ib.* 883-888——Observations relative to explosions in December 1850 and May 1852 at Middle Dyffryn Colliery, Aberdare, by which respectively thirteen and sixty-five persons were killed; character of this mine and of the ventilation adopted therein, &c., *Blackwell* 4131.

Miners. Working miners generally know nothing whatever of the ventilation of a colliery, *Mackworth* 638-642——Witness rather objects to receiving information from the workmen in coal mines direct, as it might interfere with the good feeling which should exist between master and man, *Dickinson* 903-908——In the event of regulations being issued to be observed in the mines, the pitmen would give information of any breach of the rules, *Jude* 1719-1721——Witness always encourages his men to acquaint the inspector or manager with anything amiss in the mine; their complaints are always investigated, *Forster* 4769-4778——Improved character of the miners as a body since witness first knew them; they pay much greater attention to the education of their children now than formerly, *ib.* 4840-4842.

See also *Carelessness of Miners. Coroners' Inquests. Crime. Discipline. Education. Health of Miners. Intimidation of Miners. Punishment. Roofs. Safety Lamps. Schools. Smoking. Supply of Air. Wages.*

Miners' Association. Remarks relative to the Mining Association, meetings of the delegates, &c., *Jude* 1958-1966——Reference to the Lancashire and Cheshire Branch of the Association of Miners; there are above 3,000 members; their main objects are to obtain a Government inspection and to protect wages, *Swallow* 2491-2496——In the event of any complaint being made to witness from the Miners' Association, it would be fully investigated, and witness would protect any man making complaints, *Forster* 4843-4848——Rules and regulations of the Lancashire and Cheshire Branch of the Miners' Association, established 7 November 1842; *Rep.* ii. *App.* 185-191.——*See* also *Schools*, 2.

Mining Schools. See *National Scientific Institutions. Schools.*

Monkwearmouth Colliery. Remarks on the ventilation of the Monkwearmouth Colliery; it is carried on by means of a furnace, *Henderson* 2333-2341. 2375-2384——The system of long-wall work has been in practice about three years in the colliery; witness prefers it to the ordinary board-and-wall system, *ib.* 2375-2384——Remarks relative to the accident which occurred at Monkwearmouth in consequence of a shot of gunpowder being let off in a pit where there was a great accumulation of fire-damp; this was very imprudent, as they were working on the long-wall system, *Forster* 4790-4796.

See also *Fourdrinier's Apparatus.*

Morfa Colliery. Temperature of different parts of the shaft in the Morfa Colliery, as taken by witness on a recent occasion, *Gray* 3138-3140——Remarks of Mr. W. Gray on the steam-jet ventilation at Morfa Colliery, *Rep.* ii. *App.* 92——Rules and regulations to be observed by workmen employed at the colliery, *ib.* 92-94.

See also *Ascent and Descent of Mines*, 2. *Steam-jet*, 2. 4.

Motte's Ventilator. Plan of Motte's pneumatic screw, *Rep.* i. *App. Plan* (A.)

Mueseler's Lamp. The Mueseler lamp is the one which is most commonly used; very great confidence is placed in it in Belgium, *Dickinson* 299-302——The glass safety-lamp by Mueseler could be very advantageously introduced into the English collieries, *Mackworth* 1589-1591.—— *See* also *Safety Lamps*, 5.

N.

Naked Lights. Naked candles are used in mines in Belgium which do not contain fire-damp, *Dickinson* 293-296——Witness considers a furnance to be a naked light, *Mackworth* 555-559——Reference to an accident which occurred about three years ago in a colliery under the superintendence of witness; seven men were killed by an explosion of damp; the cause of the explosion was attributed to the use of open lights, *Gray* 3009-3016——Since that period safety-lamps have been used, and not a single accident has occurred in the same mine, *ib.* 3017-3022. 3074-3076——As a general rule, naked lights should not be carried about in the vicinity of the goaves, *Wood* 3655——Many accidents have arisen from the use of naked lights, which would not have occurred if the Davy

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Naked Lights—continued.

Davy or other safety-lamps had been employed, *Wood* 3827, 3828——Witness delivers in a list of explosions, involving altogether the loss of about 1,100 lives; with a few exceptions, these explosions arose from the use of naked lights, *Blackwell* 4092-4094.

See also *Middle Dyffryn Colliery.* *Safety Lamps*, 3. *Ventilation.*

National Scientific Institutions. Suggestion for the formation of mining schools, in which persons can be rendered properly qualified in every way for the management of collieries; mode in which these schools should be supported and conducted, *Wood* 3849-3860——Sketch of a school proposed by witness to be formed at Newcastle for the efficient training of managers; the coalowners are ready to subscribe towards it, and assistance is expected from Government, the University of Durham, and the Museum of Practical Geology, *ib.* 3849-3856——Parties requiring scientific knowledge in the proposed schools could also obtain practical knowledge by periodical visits to the mines, *ib.* 3854-3856——In the event of these schools being established, it should be compulsory on the coalowners to employ only such persons as managers or otherwise who had passed the necessary examinations therein, *ib.* 3857-3860——Objections to Mr. Wood's suggestions for educating the officers of mines by means of a national scientific institution, *Blackwell* 4078-4081.——*See* also *Board of Trade.*

Natural Brattice. Witness does not agree with the Committee of 1852 as to the existence of a natural brattice, *Mackworth* 1573, 1574——There can be no such thing as a natural brattice; grounds for this assertion, *Gray* 3078, 3079. 3135-3137. 3141; *Wood* 3656-3658——Over a period of forty years, witness in using the furnace has never experienced anything like a natural brattice in practice, *Wood* 3736-3739.

Natural Ventilation. An immense quantity of ventilation on the Continent is carried on by natural ventilation, *Dickinson* 132. 175, 176——In some cases a sufficient current of air is obtained by natural ventilation, but it is not to be relied on, *Mackworth* 783——Natural ventilation is only applicable to mines under extremely favourable circumstances, *ib.* 1558——No colliery should be carried on with merely natural ventilation; some artificial system should be imperative, *Wood* 3635-3639——Natural ventilation is sufficient for the mines in South Staffordshire, except in the summer months, *Blackwell* 3939-3941. 4036——Remarks by Mr. N. Wood on the subject of natural ventilation; result of experiments, &c. *Rep.* iii. *App.* 118. 148, 149-152——Experiments made at the Seaton Pit on natural ventilation; depth and diameter of pit, &c., *ib.* 119——Table of natural ventilation in Hetton and Tyne Main Collieries, *ib.* 170.——*See* also *Prussia.*

Newcastle School. See *National Scientific Institutions.*

Nitshill Colliery. Remarks as to the explosion at Nitshill Colliery, in Scotland; there was no artificial means of ventilation; they trusted entirely to nature, *Cayley* 1549-1551——Statement as to the explosion; opinion that this mine could not have been properly ventilated, as stated in the report of Mr. Dunn, the Government inspector; paper on the subject delivered in, detailing the system of ventilation adopted, &c.; sixty one persons were killed by the explosion, *Blackwell* 3984-3993. 4131.

Norwood Colliery. Result of experiments made by Mr. Greenwell at the Norwood Colliery for the purpose of testing the comparative powers of the furnace and the steam-jet, *Rep.* iii. *App.* 144. 151.

O.

Overmen. Remarks as to the duties performed by the overmen in mines; one element which witness would recommend as contributing to the safety of mines would be a more careful superintendence, *Dickinson* 365-370——The overmen employed in the South-western District are, on the average, not very intelligent; great deficiency of information among them on any important points of safety, *Mackworth* 768-772——Remarks as to the class of men acting as overmen in the mines; in some parts of the country they are of a much superior class than in other parts, *ib.* 1587——Number of overmen and deputies employed in coal mines, *Jude* 1846-1849——With regard to the overmen, they are not generally a well-qualified class of men; means by which they might be improved, *ib.* 2013-2020——Class of men from which witness usually selects his overmen, *Forster* 4786-4789.——*See* also *Discipline.* *Sub-inspectors.*

Owners of Collieries. The system of inspection in Belgium does not diminish the sense of responsibility on the part of the owners of mines, *Dickinson* 413——The expense of serious accidents by explosions is almost invariably very great on the owner; thus it is his interest to keep the mines in the best state possible, *ib.* 1411-1413——The responsibility should rest on the coal proprietors, and they should be subject to persecution in the event of accidents occurring through their neglect of proper precautions, *Blackwell* 4089-4092. 4098. 4121, 4122. 4127-4130.

See also *Explosions.* *Magistrates.* *Rules and Regulations.* *Ventilation.* *Working of Mines.*

Reports, 1852-53—*continued.*

P.

Pasquet's Ventilator. Plan of Pasquet's ventilator fan, *Rep.* i. *App. Plans* (B & C.)

Pemberton Pits, Wigan. Experiments made with respect to the steam-jet and furnace ventilation at the Pemberton Pits, Ince Hall Colliery, Wigan, and results thereof, *Dickinson* 1109.

Pillar-and-Stall System. The most convenient way is to work the coal first by stall and pillar and then by long-wall work, *Mackworth* 811——The Seaton Delaval Mine is worked by pillar and stall, the ordinary work of the north of England, *Dickinson* 1008–1013——Mode suggested for reducing the wastes under the pillar-and-stall system so as not to leave large deposits of gaseous matter in the mine, *Blackwell* 3964, 3965.

See also *Escapes of Gas. Long-work System. South Wales. Working of Mines.*

Plans of Collieries. With regard to the plans of mines, the Act should be more stringent than it is at present; frequency of mines being worked without plans; plans in all cases should be made of collieries and enforced by penalties, *Dickinson* 913–932——Frequency of accidents arising from borings being made into old workings filled with water, in consequence of the absence of plans of the workings, *ib.* 916–931——It is essential that the Government inspector should have the power of enforcing a regulation that proper plans of all collieries should be kept, *Mackworth* 1599–1601.

Pneumatic Flower-pot. The pneumatic flower-pot was not established in the experiments made by witness with the steam-jet, *Wood* 3511–3514——The application of the jets was so arranged by Mr. Wood, that the air being driven up in front of the jets would naturally return again around them or by the sides of the cylinders, and thereby supply the exhaustion below, forming what is termed the pneumatic flower-pot, *Gurney* 4265–4272. 4286–4292——If the steam-jets were placed at the top of pit and the cylinders were of too great a diameter there is a liability of the return air passing down the inside tubes, which is called the pneumatic flower-pot, but with the jets placed at the bottom it is impossible, *Forster* 4522–4533.

Pressure of Air. Table of the pressure of the air in lbs. avoirdupois per square foot of surface or area of shafts of different depths, and subject to different degrees of temperature, *Rep.* iii, *App.* 123.——*See* also *Steam-jet*, 1.

Prussia. List of accidents in coal and other mines in Prussia during the years 1847, 1848, 1849, 1851, and 1852, *Dickinson* 421——List of accidents in coal mines only, 1847 to 1851, *ib.*——There is very little fire-damp in Prussia, which accounts for the few accidents arising from that cause, *ib.* 441–444——The precautions in Prussia with regard to ventilation are very slight indeed; the majority of the mines are carried on by natural ventilation, *ib* 444——There is nothing in the Prussian system witness would recommend to be adopted in this country, except the fencing of the pits, *ib.* 445——The Government stand in a position similar to the lessors of mines in this country, *ib.* 448–452——The Government receive five per cent. of the profits from one portion of the kingdom, and five per cent. of the produce from another portion, *ib.* 451.

See also *Fire-damp. Inspection of Mines*, II. 3.

Punishment. Opinion that the law as it exists at present is sufficiently stringent in punishing men who are guilty of an infraction of regulations, if the law was properly administered, *Dickinson* 371–375——If there were a specific enactment for punishing men in case of their endangering the lives of their fellow-workmen by opening their lamps or smoking, a great moral effect would be produced, *ib.* 412——Frequency of some workmen committing reckless acts so as to endanger the safety of other men; difference of opinion among the magistrates as to their power of inflicting fines in such cases, *ib.* 1283–1291.

See also *Carelessness of Miners.*

Q.

Qualification of Officers. Suggestion for the formation of some tribunal for examining into the qualifications of the managers and officers of mines; a Board might be formed of some of the principal mining engineers in the country; this would be preferable to any Government Board, *Jude* 1991–1997——Generally speaking, the officers in management of mines are extremely deficient in the qualifications that are requisite, *ib.* 1998 *et seq.*——Remarks on the low qualifications of the managers of the various collieries in Lancashire, Cheshire, and Yorkshire, *Swallow* 2877–2884——Suggestions as to the best means of qualifying persons for the management of collieries; each manager should have served an apprenticeship as a practical miner, *ib.* 2885–2895.

See also *Managers of Collieries. National Scientific Institution. Overmen. Under-viewers.*

Reports, 1852-53—*continued.*

R.

Reading-rooms, &c. Owners should allow all fines and forfeitures on the workmen's wages to go to a fund for the purpose of establishing reading-rooms, libraries, and having lectures upon scientific subjects, *Jude* 2227-2232.

Reflecting Lamp. Since the recommendation of the last Committee, reflecting safety-lamps have been tried, but have failed from the tin melting off the reflectors; opinion that they would melt were they silver-plated, *Dickinson* 333-339.

Refuge Stalls. Opinion that refuge stalls for the men to fly to in case of explosions are not practicable; remarks in support of this opinion, *Mackworth* 1582; *Wood* 3659-3665——Observations with respect to the practicability of constructing refuge stalls, *Jude* 1970-1983——Witness has had no experience of the subject of refuge stalls, but believes that in the event of explosions they may be the means of saving many lives, *Swallow* 2563-2576——The safest place after an explosion is in the face of the boards, where the air is pent up to a certain extent, *Wood* 3664, 3665——Opinion that refuge stalls would not be of any advantage, as they would soon be filled with choke-damp, *Forster* 4605-4611.

Regulations. see *Rules and Regulations.*

Report of 1852. The body of miners highly approve of the recommendations contained in the Report of the Committee of 1852, *Jude* 1737, 1738——How far witness agrees with the Report of 1852, *Swallow* 2541 *et seq.*

Resistance of the Air. Remarks by Mr. N. Wood on the subject of the resistance of the air in coal mines, *Rep.* iii. *App.* 128, 129.

Return Air. In this country it is considered perfectly safe to work the return air over the furnace; the furnace works most economically when all the return air is worked over it, *Dickinson* 211-215——Peculiarity with regard to the system of ventilation as to return air; this is particularly attended to in Belgium; it is a very important principle in ventilation, *ib.* 414-420.——*See* also *Air-ways. Doors.*

Risca Black Vein Pit. Extracts from reports on the subject of an explosion in 1846 on the Risca Black Vein Pit, by which thirty-five lives were lost; state of the ventilation, and suggestions for its improvement, *Blackwell* 4131.

Roberts's Lamp. Peculiar and ingenious construction of Mr. Martin Roberts's lamp, which extinguishes the flame in the event of the glass being broken, *Wood* 3793-3796.

Roofs. Observations with respect to the roofs of coal mines; the system of long work is applicable to roofs of various descriptions, *Dickinson* 76-88——With regard to precautions against falls of roof, the system which is adopted in the north of England of making the deputies set the props, tends to a considerable saving of life, and is almost universally employed on the Continent, *Mackworth* 1595, 1596——Frequency of accidents from the falls of the roof in mines; this might be avoided by more hands being employed as deputies, to see that sufficient pit props are placed, *Jude* 2118-2133. 2204-2212; *Forster* 4612-4618——With respect to the falling of roofs, the deputies are the most fit persons to see that sufficient timber is furnished to stand the roofs, *Jude* 2204-2212; *Henderson* 2344-2348; *Wood* 3682-3684; *Forster* 4612-4618——With regard to accidents from falls of roofs, it is better for the miners to set their own timber and place the props, than for the deputies to do so, *Swallow* 2776-2780; *Tetlow* 3320, 3321.

In the Morfa Colliery the workmen prop the roofs; only one man has been killed from a fall of coal; proper attention is not generally paid to the timbering of the roof, *Gray* 3123. 3127-3129——Approval of the principle of the employment of deputies in coal mines, *ib.* 3124-3126——Sufficient timber is generally supplied for the purpose of standing the roofs, *Swallow* 2776-2780; *Tetlow* 3322, 3323; *Wood* 3685-3688——Care and attention are the best precautions against accidents from falls of roofs, *Wood* 3682-3684.——*See* also *Long-work System.*

Rules and Regulations. Recommendation that a certain number of the most important regulations for the working of coal mines be passed into a law; a code of regulations could be adopted which might be applied universally throughout the country, *Dickinson* 437-440; *Mackworth* 732-740. 751-760. 773. 1610-1621. 1670-1676; *Tetlow* 3233-3235; *Forster* 4745-4748. 4763-4768——Existence of a very excellent collection of rules for collieries, which are part of the laws of Belgium; rules for the workmen as well as for the masters, *Mackworth* 703-708——In ordinary managed mines in Belgium the system is infinitely superior to the system in England; this is attributable to the admirable code of regulations, *ib.* 727-730——Although there is a great difference with respect to the fiery nature of mines, still regulations might be framed that would apply to all descriptions of mine, *ib.* 775-781——The improved inspection of mines ought to be combined with a code of regulations, which the inspectors should see enforced, *ib.* 875-877.

Reports, 1852-53—*continued.*

Rules and Regulations—continued.

List of rules and regulations which might be laid down as fundamental rules for the management of every colliery in the country, *Dickinson* 897——Copy of the rules and regulations to be observed by the workmen employed at the Morfa Colliery; remarks thereon, *Gray* 3080-3093——Mode in which the regulations might be drawn up and established; it would be difficult at first to strike out a law satisfactory to all parties, *Tetlow* 3234-3237——A code of rules and regulations should be determined upon by consultation between the inspectors and the principal viewers and coalowners in the kingdom; these rules should be made the law of the land, and should form the basis of the system of inspection, *Wood* 3875-3891——The rules proposed by the inspectors who have been examined before the Committee do not go far enough, but are otherwise not objectionable, *ib.* 3884-3886.

In consequence of the different characters of coal mines, and the different systems of working, no general law can be made applicable to the entire country, *Blackwell* 3934-3938——Witness has published a set of rules for the use of his collieries; there is no difficulty in enforcing them, *Forster* 4779-4785——The proprietors of collieries would not object to be bound by rules and regulations laid down by practical men, but it would be a great hardship to be bound by compulsory powers put over them by incompetent persons, *ib.* 4812-4817——Willingness of witness, in connexion with Mr. Wood and other principal viewers, to consider and frame a code of rules which would be generally applicable to be enforced by law in the several collieries; necessity for the inspectors being present at these meetings, *ib.* 4851-4854.

See also *Miners. Punishment. Safety Lamps*, 2. *Supply of Air.*

S.

Safety Lamps:

1. *Generally.*
2. *Evidence as to the relative Merits of several Descriptions of Lamps.*
3. *Great Carelessness of the Miners with the Lamps; importance of their being kept Locked.*
4. *Necessity for the Lamps being placed under the Care of some Person specially appointed for the purpose.*
5. *Remarks as to the Safety Lamps in use in Belgium.*

1. *Generally:*

Opinion that the lamp is a very accurate means of testing the safety or danger of mines, *Dickinson* 202-207——How far any advantage would result from having the wires of the lamp polished perfectly bright; this might increase the light, *ib.* 324-332——It is very desirable to have a safety-lamp of some kind which will give the miners a better light, without unscrewing the top, *ib.* 340-346——The lamp is not to be considered an absolute security under all circumstances; with a current of eight miles an hour through the meshes of the lamp there would be a chance of an explosion, *ib.* 388-402——Reference to the Report of the Committee of 1852, with regard to safety-lamps; how far witness agrees with that Report, *ib.* 1291, 1292——The use of the lamp should be left to the discretion of the inspector, and to some extent to the manager, *ib.* 1294-1296——The inspector should at all times have power to order the use of lamps in a fiery mine, *ib.* 1331.

The use of safety-lamps should be rendered compulsory in all fiery collieries, *Mackworth* 1591; *Jude* 1822-1824; *Tetlow* 3307-3311——Remarks to the effect that a safety-lamp is a very dangerous instrument in the hands of workmen and boys; grounds for the opinion that the Davy lamp is unsafe, *Swallow* 2542-2559. 2713-2763——The danger of explosion arises from the retrograde motion, and witness has seen explosions of safety-lamps caused thereby, *Gurney* 4331, 4332. 4337-4342——The lamp is a great safeguard, but it ought not to be entrusted in the hands of men in an explosive mixture, *Forster* 4661-4685——Witness would be very glad to have a better safety-lamp, if it could be constructed, *ib.* 4663, 4690.

2. *Evidence as to the relative Merits of several Descriptions of Lamps:*

Description of the safety-lamps in ordinary use in this country; the Davy lamp is most generally used; the Stephenson lamp is coming into general use, *Dickinson* 1297-1299——Comparative merits of the several lamps, with regard to their illuminating power: the Eloin lamp gives the best light, but it is generally attended with the disadvantage of going out in a brisk current of air; preference to be given to Dr. Glover's lamp, *ib.* 1336-1345——Remarks relative to different lamps; the workmen prefer the Stephenson lamp to the Davy lamp, *Jude* 1730-1736——Witness has invented a safety-lamp for miners; explanation as to the construction of the same, showing how far it possesses any advantages over the Clanny and Davy lamps, *Henderson* 2270. 2280-2307.

Examination as to experiments made by witness on several lamps, in order to test their respective merits, *Wood* 3740-3828——Result of the experiments on lamps constructed

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Reports, 1852-53—*continued.*

SAFETY LAMPS—continued.

2. *Evidence as to the relative Merits of several Descriptions of Lamps*—continued.

on the principle of admitting a limited quantity of atmospheric air, the security and insulation of the lamp being attained by glass or talc; all these lamps were put out when inserted in an inflammable mixture, *Wood* 3743-3746. 3752-3759——Witness tested the Stephenson, the Clanny, and Dr. Fife's lamps; result of these experiments, *ib.* 3763-3765. 3780-3785. 3793. 3804——With respect to lamps having a diminished quantity of air entering and feeding the flame, and with the use of glass, there is occasion to have the insecurity of the wire gauze upon the top of them, *ib.* 3765, 3766. 3803——Species of top recommended for safety-lamps; a lamp with a properly constructed top and two cylinders of glass is the safest, *ib.* 3786-3789. 3803——Remarks to the effect that witness is convinced by experiments and by practice of the security afforded by safety-lamps; suggestions as to the rules and regulations that should accompany their use, *ib.* 3805-3828.

Observations generally on the subject of safety-lamps; exception taken by witness to Mr. Wood's statement that under certain conditions the Davy or other lamps would not explode; the Davy lamp, as shown by frequent experiments by scientific men, explodes at four feet rate of current, *Gurney* 4328-4342——Result of experiments with several lamps at Killingworth Colliery, to test at what velocity in an explosive mixture of fire-damp and atmospheric air the flame may be passed through the wire gauze, *Rep.* iii. *App.* 173, 174——Experiments made to test various safety-lamps, tried at Wallsend Colliery on 28 June 1853, *ib.* 175, 176.

3. *Great carelessness of the Miners with the Lamps; importance of their being kept Locked:*

Frequency of the miners in this country unscrewing the top of the safety-lamps and working by the naked flame on account of the gauze obstructing the light; this is a punishable offence; the evil is not near so frequent among the miners in Belgium, *Dickinson* 311-323——It would be advantageous if the lamps were always locked to prevent the miners opening them, *Dickinson* 405-411; *Mackworth* 1685, 1686; *Jude*, 1842, 1843; *Henderson*, 2322-2325; *Forster* 4686-4689——The use of locked lamps should be compulsory in every colliery where there is any fire-damp at all; this is an important rule, and ought to be generally applied, *Mackworth* 780-834. 872, 873——Suggestion that it should be made an offence against the law for a workman to take off the top of his lamp, *Gray* 3043-3055——The miner should not be entrusted with a key of the lamp, nor allowed to take the top off, *Wood* 3813-3815. 3822, 3823.

4. *Necessity for the Lamps being placed under the Care of some Person specially appointed for that purpose:*

The safety and sufficiency of the lamp depends altogether upon its being kept clean; system pursued in Belgium to ensure the cleaning of the lamps, *Dickinson* 333-335——Necessity for the safety-lamps being well looked after; some person should be appointed to the duty of inspecting the lamps every morning before they are used, and the collier should also be held responsible for the efficiency of his lamp, *ib.* 347-364——The cleaning of the lamps should not be left to the miners; there should always be a lamp-man, *Mackworth* 1602-1607. 1675; *Jude*, 1841——Precautions necessary to be taken with respect to the cleaning and repairing of the lamps, *Henderson* 2326-2331——Remarks, generally, on the precautions taken in witness's pit in the use of safety-lamps; they are properly cleaned and repaired, and a heavy fine is imposed on any one who unlocks them, or takes the top off without authority, *Gray* 3034-3055. 3068-3077——The lamps should be inspected daily by competent persons before they are taken into the mine, *Wood* 3810-3812——In the north of England the lamps are placed under the superintendence of men appointed for that purpose, *Forster* 4688.

5. *Remarks as to the Safety Lamps in use in Belgium:*

Particulars as to the use of the safety-lamps in the Belgian mines; there are only four lamps which are approved by the Government, namely, Davy's, Mueseler's, Boty's, and Eloin's; difference in the cost of these lamps, *Dickinson* 293-310——The proprietors of the mines in Belgium provide the lamps, *ib.* 310——All the lamps should be kept locked, and the key kept by the man who has to clean the lamps daily; this is the law in Belgium; and is quite practicable, *Mackworth* 1682-1686.

See also *Barnsley District.* *Clanny Lamp.* *Davy Lamp.* *Eloin Lamp.* *Fife's Lamp.* *Glover's Lamp.* *Hall's Lamp.* *Mueseler's Lamp.* *Naked Lights.* *Punishment.* *Reflecting Lamp.* *Roberts's Lamp.* *Velocity of Currents.* *Wire-gauze Lamps.*

Reports, 1852–53—*continued.*

Schools:

1. *Recommendations for the Establishment of Mining Schools; Education to be provided therein.*
2. *Manner in which the Fund for the Support of these Schools is to be obtained.*

1. *Recommendations for the Establishment of Mining Schools; Education to be provided therein:*

Suggestion for the establishment of schools for the use of colliers and their children; beneficial results that would arise therefrom, *Dickinson* 1358–1368; *Mackworth* 1587, 1588; *Tetlow* 3335–3339; *Blackwell* 3930; *Forster* 4797–4802——Evidence with respect to the schools established at the collieries in the north of England; deficiency in the means of education among the mining classes, *Jude* 2021–2036——Nature of the instruction that should be afforded in the colliery schools; practical information with respect to mining might be given in evening schools, *ib.* 2048–2057——Children should be compelled to attend the colliery schools; a certificate of a boy's having attended should be required before he was permitted to enter a mine, *ib.* 2068, 2069——Schools for the children of miners are not general in Lancashire, *Swallow* 2896, 2897——A certain amount of school attendance should be required on the part of all miners' children under a certain age, *Blackwell* 4079, 4080.

2. *Manner in which the Fund for the Support of these Schools is to be obtained:*

The establishment of schools for the children of the workmen in collieries might be adopted without inflicting a great hardship on the colliery proprietors; manner in which the funds for such schools might be provided, *Dickinson* 1358–1368——Opinion that if the establishment of a school was made compulsory on each colliery, a rate for their support being stopped from the earnings of the workmen, it would take very well with the miners, they themselves having some control in the management, *Jude* 2037–2047; *Forster* 4831–4842——With respect to the schools, the Mining Association are anxious that the Government should contribute 20 *l.* per annum for every 100 *l.* contributed by the coal-hewers in the colliery, *Jude* 2226–2230——Witness deducts weekly from the earnings of each man 1 ½ *d.* for school, the same sum for the surgeon, and the same for the sick fund; the men do not object to this deduction, *Gray* 3150–3153.

The miners would not object to contribute from their wages towards the support of schools, but might expect the same assistance from Government as is afforded to factory schools, *Tetlow* 3349–3355——The owners of collieries almost universally subscribe towards schools for their workmen's children, *Wood* 3903–3910——The practice of deducting a small amount from the earnings of the men, and giving them a voice in the management of the schools has not been found to work well, *ib.* 3906, 3907——The miners are generally willing enough to subscribe towards their children's education, *ib.* 3908–3910.

See also *Education. Employment of Children. National Scientific Institutions.*

Scotland. Statement as to the practice in Scotland with regard to accidental deaths in mines; the system pursued renders the owners and managers more careful, but it is carried to an extreme, *Dickinson* 1240–1245.

Seaton Delaval Colliery:

1. *Evidence generally with respect to the Ventilation of this Colliery.*
2. *Particulars as to certain Experiments with the Steam-jet and Furnace.*

1. *Evidence generally with respect to the Ventilation of this Colliery:*

Depth of the main shaft at Seaton Delaval; the colliery is ventilated by four down-cast shafts and one up-cast shaft, *Dickinson* 974–978——The Seaton Delaval application of the steam-jet is not one of the best witness has seen; the jets as recently applied by Mr. Darlington, at Ince Hall, are done in a superior manner to Seaton Delaval, *ib.* 968–971. 1079–1083——Statement of the ventilating power at Seaton Delaval; way in which the steam-jet is applied; great number of steam-jets employed, *ib.* 979–986——Opinion that the steam-jet, with the additional temperature of the up-cast shaft, caused by the increased consumption of coal and the more perfect combustion, can only operate as a power to the extent of 3,600 cubic per minute, *ib.* 1076–1078——Witness does not consider the ventilation difficult in the Seaton Delaval Colliery at the rate of 33,000 feet a minute, considering the large quantity of coal raised and the number of men at work, *ib.* 1100–1102——Evidence relative to the adoption of the steam-jet system at the colliery; the ventilation is much more perfect than it was during the time the mine was ventilated by furnaces; number of jets in use and quantity of air obtained, *Forster* 4348–4397——There has been no explosion or accident at Seaton Delaval since the establishment of the steam-jet; the colliery is in a very satisfactory state as regards ventilation, *ib.* 4396, 4397.

Comparison between the ventilation of the Seaton Delaval Colliery with that of Mr. Wood's at Killingworth with the furnace: the quantity of air which is drawn through the latter is not so great as the quantity which is drawn through Seaton Delaval Colliery,

Forster

Reports, 1852-53—*continued.*

Seaton Delaval Colliery—continued.

1. *Evidence generally with respect to the Ventilation of this Colliery*—continued.

Forster 4398-4425——Statement as to the arrangement of the steam-jets; they are placed at the bottom of the pit; witness does not consider that he has arrived at the true mode of applying the jets correctly, *ib.* 4426-4441——If the number of steam-jets were increased, a much greater quantity of air might be obtained; and if the jets were placed in cylinders, a greater power would be obtained; the use of cylinders is Mr. Gurney's suggestion, *ib.* 4471-4477——Remarks as to the quantity of air passing through the Seaton Delaval mine; a large portion of this passes directly from the down-cast shaft to feed the boiler fires, *ib.* 4491-4497. 4504-4509——Circumstances under which witness abandoned the furnace and adopted the steam-jet, *ib.* 4560-4575——Number of men and boys employed in the colliery, *ib.* 4849, 4850——Sundry memorandums by Mr. T. E. Forster, relating to ventilation in the Seaton Delaval Colliery, *Rep.* iii. *App.* 183, 184.

2. *Particulars as to certain Experiments with the Steam-jet and Furnace:*

Witness, in conjunction with Mr. Dunn, Mr. Mackworth, and Mr. Wynne, made some experiments with reference to the steam-jet and furnace power at Seaton Delaval Colliery on the 15th and 16th December 1852, *Dickinson* 958-960——Mr. Forster was not present at those experiments, he having been laid up at the time from an accident, *ib.* 961-965——Report on the experiments made at the colliery, showing the results thereof, *ib.* 966, 967. 991-993——Explanation as to the manner in which the experiments were carried out, with a view of proving what was due to the steam-jet, and what was due to other causes, namely, furnaces, and the issuing of steam from the engine, *ib.* 1014-1066 —— During the experiments the under managers and resident viewer were present, and checked the measurements made at the different splits, *ib.* 1067-1083——Evidence with respect to the experiment made at the Colliery on the 15th June 1853 to prove whether the door that leads to the boiler fires being left open would lessen the current of air in the workings, when it was found to increase it, *Jude* 2233-2269—— Particulars as to the experiments made on the 18th May, *Forster* 4446-4451——Result of experiments in ventilation by Messrs. Jude and others at Seaton Delaval Colliery, *Rep.* ii. *App.* 83, 84——Return by Mr. T. E. Forster, showing the results of a series of experiments with respect to the ventilation of the colliery, *Rep.* iii. *App.* 180-183.

See also *Boiler Fires. Furnace Ventilation*, 2. *Pillar-and-Stall System. Shafts. Steam-jet*, 1. 2. *Velocity of Currents. Water-gauge.*

Self-registering Anemometers. See *Anemometers.*

Shafts. Considerable decrease in the number of accidents in shafts in 1852; this may be attributed to the Government inspection, *Mackworth* 480-511——On witness discovering any defects in the shafts of any of the mines under his inspection, he has suggested alterations and improvements to the managers, which have invariably been carried out, *ib.* 489-513——Opinion that casing the pit from the bottom to the top would be an effectual remedy against parts of the pit falling down and killing men in their descent; the expense would be very trifling, *Dickinson* 1224-1226——Insufficiency of the present number of shafts for the proper ventilation of mines; there should be two shafts sunk at the dip of the colliery, and one or two of equal area at the rise of the colliery, *Jude* 1747-1782——The intake air-way and the return air-way should remain independent, and should not be used for drawing up coals, *Swallow* 2647. 2649——The size and number of the shafts should depend on the extent of the mine and the number of men employed; there should be one shaft to every forty acres, and in no case should there be less than two shafts in every mine, *ib.* 2651-2663. 2774, 2775——Second shafts can be sunk very cheaply, or at a rate of 10*l.* per fathom, including all expenses, *ib.* 2663-2665. 2707-2712. 2822.

Examination as to the distance from the shaft beyond which it is unsafe to work collieries; opinion that it is dangerous beyond a limit from the shaft of 500 yards; they may work to a greater distance in the Ravenhead Mine, but it is not safe, *Swallow* 2666-2706——The shafts are often in a very defective state, and are not properly walled; accidents have frequently occurred in consequence of stones falling from out of the sides of the shaft, *ib.* 2781-2786. 2811. 2820——In some respects it is better to have a shaft of a small rather than of a large area, *Wood* 3421-3427——With respect to falls of stones from pits or shafts in work, it should be the peculiar province of the inspector to see that such shafts are securely walled off, *ib.* 3693-3695——If the shaft of the Seaton Delaval mine was as large as the shaft in the Hetton Colliery, the former would get a greatly increased quantity of air, *Forster* 4557-4569.

See also *Air-ways. Belgium. Brattices. Pressure of Air. Up-cast Shaft.*

Sick Clubs. See *Benefit Societies.*

Size of Air-ways. See *Air-ways.*

Reports, 1852-53—*continued.*

Smoking. Remarks relative to smoking in mines; how far any danger arises from the practice; there would be no difficulty in putting a stop to the practice if proper precautions were taken by the manager, *Dickinson* 383-387——The custom of smoking tobacco should be prohibited in the pits, *Swallow* 2908, 2909; *Wood* 3816.

See also *Punishment.*

South Hetton Colliery. See *Hetton Colliery.*

South Wales. The system of long work is applicable to the South Wales coal field; its introduction there would be the means of reducing the cost of getting the coal, *Dickinson* 43——With respect to the coal fields of South Wales, they are almost exclusively worked on the pillar-and-stall system; defective state of the air-ways in these collieries, and consequent occurrence of accidents, especially in the thick coal seams, *Blackwell* 3994-4002. 4006-4008.——*See* also *Managers of Collieries.*

South-Western District. Frequency of the ventilation in particular mines in witness's district varying materially, from the time of one visit to another, *Mackworth* 631-634.

See also *Overmen.*

Splitting the Air. In ordinary cases, with proper attention, it is quite easy to split the air, and carry it to different parts of the workings; in a large colliery it is indispensably necessary to split the air, *Dickinson* 1169-1174——Edvidence on the advisability of splitting the air into different currents; different modes by which this is at present accomplished, *Swallow* 2595 *et seq.*——A mine cannot be well ventilated without splitting the air, *Tetlow* 3299-3301——Object of splitting the air, *Forster* 4586-4592.

See also *Air-ways.* *Distribution of Air.* *Lancashire Collieries.*

Staffordshire. The explosions in South Staffordshire are attributable to a want of proper air-ways and of due precautions on the part of the workmen, *Blackwell* 4009-4011. 4028-4036——Remarks on the North Staffordshire mines; the ventilation is ordinarily imperfect, *ib.* 4012-4131——This was especially the case at the Ubberley Colliery, where an explosion occurred some few years since, *ib.* 4014-4021——Paper delivered in with respect to explosions in the South Staffordshire mines; these explosions arose from very imperfect ventilation and the use of naked lights; the collieries were those of Rounds Green, Heathfield, Friary Field, and Whitehall, *ib.* 4131.

See also *Long-work System.* *Natural Ventilation.*

STEAM-JET VENTILATION:

1. *Great Advantage of the Steam-jet as a means of effecting a proper Ventilation.*
2. *Opinion that the Steam-jet is not so Efficacious or Economical as the Furnace.*
3. *How far the Steam-jet has been used in Belgium.*
4. *Papers laid before the Committee.*

1. *Great Advantage of the Steam-jet as a means of effecting a proper Ventilation:*

There is no loss of power from friction in the use of the steam-jet, *Cayley* 1539——Observations upon the subject of the steam-jet; grounds for the opinion that the steam-jet is a more powerful agent of ventilation than the furnace, *ib.* 1539-1547——The steam-jet among the mechanical powers is a more economical agent than any other apparatus, and less liable to danger from explosion, *ib.* 1548——Remarks relative to the operation of the steam-jet in the Seaton Delaval Colliery; the ventilation of that mine is very superior to any pit witness ever saw before, *Jude* 1705-1718. 1793, 1794——The steam-jet was first introduced in 1816; witness never heard of its having been used prior to that time, *Gurney* 4133-4140——When the drag of a mine is considerable, the steam-jet should be employed more powerfully in the area of the jet and the area acted upon should be reduced, *ib.* 4144. 4148-4154——Definition of the principles of action of the steam-jet and the furnace, *ib.* 4145. 4196.

By varying inversely the areas of the jets and cylinders, any amount of power may be produced, *Gurney* 4151-4154——There is no limit to the power of the jet; by a proper application a disturbance of 300 or 400 inches of water-gauge may be produced experimentally; practically about eight inches of water-gauge has been produced in a coal shaft, *ib.* 4165-4179——The steam-jet has an excess of power of ventilation beyond what is required for ordinary purposes, which under extraordinary circumstances could be suddenly brought into play, thereby diminishing or removing the fatalities consequent on explosions through the after-damp, *ib.* 4180-4197——In deep pits the furnace may be as efficacious as the jet, and more economical, but in shallow pits the jet has decidedly the advantage, *ib.* 4198-4207——In some deep pits the steam-jet may be essentially necessary, as affording a power of ventilation without a limit, the limit of the furnace being at times extremely dangerous, *ib.* 4206-4208——The size of the cylinder in relation to that of the jet must depend on the drag of the pit, &c.; a cylinder of five inches would in most cases be sufficiently large for a jet of 1-8th or 3-16ths of an inch, *ib.* 4280-4283.

Reports, 1852-53—*continued.*

STEAM-JET VENTILATION—continued.

1. *Great Advantage of the Steam-jet, &c.*—continued.

4280-4283. 4285——The expense of the steam-jet, as regards the consumption of coal, is not much increased by enlarging the area of the jets and diminishing the size of the cylinders, *Gurney* 4284, 4285.

Great advantage of the application of the steam-jet at the top of the down-cast shaft, in the event of an explosion, *Gurney* 4323——Difference between high and low pressure steam with regard to the rate at which they severally move the jet, *ib.* 4324——The action of the steam-jet is founded on the first law of motion, namely, that bodies in motion go on for ever unless they are stopped by something, *ib.* 4325——The steam-jet has been introduced into almost every steamer on the Thames, and is being extended to the navy, *ib.* 4326——Mention of several other useful applications of the steam-jet; as applied to the blast furnace of an iron forge, the power has been got up to eight or ten inches of the water-gauge, *ib.* 4327——Witness has not applied the steam-jet to any of the collieries under his management except the Seaton Delaval, as they do not require more ventilation than they already have by the furnace, *Forster* 4480-4483——The way in which the jets are placed makes a difference in the effect they will produce, *ib.* 4538——Opinion that the steam-jet as a means of ventilation is more economical than the furnace, *ib.* 4579-4581.

2. *Opinion that the Steam-jet is not so Efficacious or Economical as the Furnace:*

None of the experiments made by witness have led him to the conclusion that the steam-jet is so efficacious or so economical as the furnace, *Dickinson* 1080——Opinion that the mechanical power of the steam-jet, without any rarefaction whatever, is a very small aid in ventilating a pit, *ib.* 1126, 1127——Instances in which the steam-jet might be usefully applied in the ventilation of mines, *ib.* 1140-1148——For the transmission of large quantities of air through coal mines the steam-jet is not sufficiently powerful unless applied in conjunction with temperature, *ib.* 1140——Remarks relative to the steam-jet; there would be an enormous loss of power if the steam-jet was applied directly to the air, *Mackworth* 1478-1489.

Circumstances under which witness has made use of the steam-jet; result of experiments at the Morfa Colliery; objection to the steam-jet apparatus as being very liable to get out of order, *Gray* 2971-2991——Experiments with the steam-jet on 29, 30, and 31 October, and on 13 November 1852, produced respectively the same results, and prove generally the inferiority of the steam-jet to the furnace; alteration in the size of jets used on these occasions, *Wood* 3374-3393. 3405-3409. 3413——Remarks on the best manner of applying the jet to the ventilation of coal mines; the experiments by witness were conducted in a proper and scientific manner, and he took every care that such should be the case, *ib.* 3547-3561. 3582-3589——The results of those experiments show that the steam-jet, though it may be useful to a trifling extent, it is an uncertain and expensive mode of ventilation, and altogether deficient as a substitute for the furnace, or as an auxiliary thereto, *ib.* 3568. 3573——Reference to the use of the steam-jet at the collieries of South Hetton and Seaton Delaval, *ib.* 3569-3572.

3. *How far the Steam-jet has been used in Belgium:*

The system of steam-jet is not used in Belgium; there is an opinion that steam-jet is not a sufficient ventilating power, *Dickinson* 155. 219-222——Remarks relative to the experiments made on the steam-jet in Belgium, *Mackworth* 1514-1519.

4. *Papers laid before the Committee:*

Comparative economy of furnace (underground and above) and steam-jet ventilators according to Mr. Glépin, *Rep.* i. *App.* 146——Paper delivered in by Mr. W. Gray on the subject of steam-jet ventilation at the Morfa Colliery, *Rep.* ii. *App.* 92——Observations of Mr. N. Wood upon the steam-jet as a ventilating power, *Rep.* iii. *App.* 124 *et seq.*

See also *Alloa Colliery. Boiler Fires. Consumption of Coal. Experiments. Furnace Ventilation. Hetton Colliery*, 2. *Hilda, St., Colliery. Killingworth Colliery Pneumatic Flower-pot. Seaton Delaval Colliery. Water-gauge. Wood, Mr.*

Stephenson's Lamp. See *Safety Lamps*, 2.

Struvè's Ventilator. Witness is disposed to consider M. Struvè's mechanical apparatus preferable to any of those in use in Belgium with reference to economical working, *Dickinson* 142, 143——Reference to the ventilation of a colliery in South Wales by M. Struvè's machinery, as recommended by witness, in lieu of the furnace; success of this recommendation, *Blackwell* 4037, 4038.——*See* also *Fabrey's Ventilator.*

Sub-Inspectors. Suggestion for the employment of sub-inspectors for the assistance of the inspectors of coal mines, with powers nearly equal to those possessed by the present inspectors, *Mackworth* 732-767. 874.——The appointment of sub-inspectors would relieve the inspector of the most laborious part of his duties, but would be very strongly

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opposed by the colliery owners, *Dickinson* 890-892——Opinion in favour of the appointment of sub-inspectors; this would give great satisfaction to the workmen; number of sub-inspectors that would be necessary; nature of their required qualifications, *Jude* 1917-1946——The working men would contribute towards the expense of the sub-inspectors if they had some little power in the nomination of them, *ib.* 1967-1969——The sub-inspectors should thoroughly examine the mines, but should not interfere at all with the mode of working, so as in the least to remove the responsibility from the viewers or managers, *ib.* 2100-2117.

Evidence as to the best course to be pursued with respect to the appointment of inspectors and sub-inspectors; the sub-inspectors should be selected from practical miners; advantages to be derived from a proper system of sub-inspection, *Henderson* 2385-2405——Remarks as to the class of men most suitable for sub-inspectors; opinion that selections from practical working colliers are the most competent that can be made, and the most likely to give satisfaction to all parties, *Swallow* 2498-2516; *Tetlow* 3267-3279. 3282, 3283. 3287-3292——Necessity of a sufficient number of sub-inspectors, who should traverse the remote workings of every pit, and point out any evils that existed; if these were not remedied, he should report them to the inspector, *Tetlow* 3249-3251——Satisfaction of the miners with the Report of the Committee of 1852, more especially with the recommendations for the appointment of sub-inspectors, *ib.* 3263. 3305, 3306——The sub-inspectors should be appointed by Government, through some central Board, *ib.* 3264-3266.

Opinion that miners would easily be found quite competent to the duties of sub-inspectors, *Tetlow* 3287, 3288. 3332-3334—— Recommendation that the sub-inspectors be well paid for their services, *ib.* 3289——The suggestion to appoint sub-inspectors from practical miners is very objectionable, *Wood* 3848. 3879-3883; *Blackwell* 4099. 4105, 4106——Objection to the sub-inspectors being appointed from the overmen or underviewers, *Wood* 3849——Objection to the appointment of sub-inspectors; as they and the overmen would be constantly quarrelling, *Forster* 4723.

Supply of Air. In the code of regulations recommended by witness he would not stipulate any fixed quantity of air for the supply of a mine, *Mackworth* 773, 774——Observations as to how far regulations might be adopted to enforce the requisite supply of air to mines so as to keep them in safe and proper working order; manner in which the sufficiency or insufficiency of the supply might be measured, *ib.* 818-835——Nature of the grievances complained of by the miners; the workmen are anxious that there should be a sufficient quantity of air; the owners being responsible for such quantity, *Jude* 1697-1704——What the miners really want is sufficient ventilation whilst working; they should be enabled to complain to the inspector in the event of the supply of air being insufficient, *ib.* 1825-1837.

There cannot be too much air passing through any mine; it should be compulsory on the managers to supply a certain quantity per minute to each man, *Swallow* 2533-2540. 2595 *et seq.*; *Gray* 3144-3149——A colliery with workings to the extent of 1,000 acres may be thoroughly ventilated with 50,000 or 60,000 cubic feet of air per minute; the quantity of coal worked in such a colliery would be about 120,000 tons a year, *Wood* 3454-3456——The existence of noxious air in a mine depends much on the extent of open face at which the men are working; the amount of ventilation should be regulated by the extent of face, *ib.* 3461-3465——Every miner should have a certain quantity of air, and it should be the duty of the inspectors to see that such is the case, *ib.* 3632-3634——Remarks as to the quantity of air required by each miner: 500 cubic feet per minute is more than sufficient under ordinary circumstances, *Blackwell* 3943-3948.

See also *Distribution of Air.* *Mechanical Ventilators*, 3. *Shafts.*

Swallow, David (Analysis of his Evidence.)—Resides at Romford, near St. Helen's, 2459——Witness is corresponding secretary to the Lancashire and Cheshire Branch of the Miners' Association; nature of his duties, and extent of his experience on the subject of mining in different counties, 2460-2474——Remarks on the subject of a Government inspection of mines; the appointment of inspectors has been very beneficial in the prevention of accidents, 2475-2520. 2525, 2526. 2531, 2532. 2764-2773. 2928-2936——The inspection, however, is far from satisfactory; the number of inspectors is not sufficient, and their powers are much too limited, 2483-2490——One inspector should not have power to stop the working of a colliery; suggestion that there be a number of sub-inspectors appointed, and that he take counsel with them as to the advisability of closing any mine, 2489, 2490.

Reference to the association of miners with which witness is connected; there are above 3,000 members; their main objects are to obtain a Government inspection and to protect wages, 2491-2496——The sub-inspectors should be appointed from the most intelligent practical miners; their chief duty should be to report the state of the mines to the inspector placed over them, 2498-2516——Some collieries should be visited by the inspectors within certain periods, but this rule should only apply in peculiar cases, 2517-2520——Artificial ventilation should be enforced in every colliery, but no particular system should be specified, 2521-2531——There cannot be too much air passing through any mine;

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mine; it should be compulsory on the managers to supply a certain quantity per minute to each man, 2533-2540. 2595 *et seq.*——How far witness agrees with the Report of the Committee of 1852; 2541 *et seq.*——Remarks to the effect that a safety-lamp is a very dangerous instrument in the hands of workmen and boys; grounds for the opinion that the Davy lamp is unsafe, 2542-2559. 2713-2763.

Objection to putting down bore-holes, 2560-2562——Witness has had no experience on the subject of refuge-stalls, but believes that in the event of explosions they may be the means of saving many lives, 2563-2576——Reference to an explosion in the Ardsley Main Colliery, near Barnsley, by which seventy-three men were killed; most of these men could have got into the air-passages if there had been any unobstructed, 2573-2585——The obstruction of the air-passages round the remote workings is the main cause of loss of life in collieries; mode suggested for remedying this evil, 2577-2591. 2619-2624——Opinion that the self-registering anemometer is not a proper test of the ventilation, 2592-2594——Evidence on the advisability of splitting the air into different currents; different modes by which this is at present accomplished, 2595 *et seq.*——Necessity of having sufficient air-ways of proper dimensions in order to carry the air well through the workings, 2619-2623. 2647-2652.

With respect to the goaves, the gas should not be allowed to remain in them; suggestions as to the best means of ventilating the goaves and of driving out the gaseous air, 2624-2646——The intake air-way and the return air-way should remain independent, and should not be used for drawing coals, 2647. 2649——The size and number of the shafts should depend on the extent of the mine and the number of men employed; there should be one shaft to every forty acres, and in no case should there be less than two shafts in every mine, 2651-2663. 2774, 2775——Second shafts can be sunk very cheaply, or at a rate of 10 *l.* per fathom, including all expenses, 2663-2665. 2707-2712. 2822——Examination as to the distance from the shaft beyond which it is unsafe to work in collieries; opinion that it is dangerous beyond a limit from the shaft of 500 yards; they may work to a greater distance in the Ravenhead Mine, but it is not safe, 2666-2706.

With respect to accidents from falls of roofs and sides, it is better to allow the miners to undertake the propping of the roofs than the masters; there is generally sufficient timber found for the purpose, 2776-2780——The shafts are often in a very defective state, and are not properly walled; accidents have frequently occurred in consequence of stones falling down from out of the sides of the shaft, 2781-2786. 2800-2811. 2820——Many accidents also arise from the employment of persons not properly qualified in winding the miners up and down the shafts, 2787-2795——It should be the duty of the inspector to see that proper engine-tenters are employed, that the shafts are properly walled, and that there is a sufficiency of timber for the purpose of propping roofs, 2796. 2814-2823——The custom of letting a man down the shaft while a full waggon of coals is going up is very dangerous, and should be prohibited, 2797-2799.

Boys under fifteen years of age are not allowed to wind up and down the shafts; the age of such boys should not be under eighteen years, 2812, 2813——Objection to the present system of coroners' inquests with respect to accidents in coal mines; the coroners should be practically acquainted with mining, and the juries should be differently constituted, 2824-2862——Government inspectors, such as Mr. Dickinson, would be very well qualified for coroners, but they should not also retain their inspectorships, 2838-2849——Half of the jury should be miners and the other half should be independent parties otherwise engaged in life, 2850-2857——A power to assess damages should be given to a coroner and jury thus constituted, 2858-2862——Magistrates, rather than the inspectors or the Secretary of State, should be empowered to inflict penalties or fines upon the owners of collieries who neglect to perform their duties, 2863, 2864.

How far sufficient enactments are at present provided against workmen who have been guilty of carelessness or recklessness whilst in the colliery, 2865-2876——Remarks on the low qualifications of the managers of the various collieries in Lancashire, Cheshire, and Yorkshire, 2877-2884——Suggestions as to the best means of qualifying persons for the management; each manager should have served an apprenticeship as a practical miner, 2885-2895——Schools for the children of the miners are not general in Lancashire, 2896, 2897——It should be compulsory on the parents to contribute a certain sum weekly towards the education of their children, 2898-2901——Difficulty of establishing a national fund from the earnings of the miners towards the support of the widows and orphan children, 2902-2907——If safety-lamps are used, blasting should be prohibited, and also the custom of smoking tobacco in the pits, 2908, 2909——The miners consider that there should be no further delay in legislating for a better system of ventilation, and expect to derive many benefits, if the Report of the Committee of 1852 is carried into effect, 2911-2927.

T.

Temperature of Air. Fire-damp and atmospheric air both expand by increased temperature; reason why the change is likely to be a cause of danger in the mines, *Dickinson* 123-125——Particulars relative to the temperature of the atmosphere as measured at the

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the time of the experiments with the steam-jet at Seaton Delaval Colliery, *Dickinson* 987-990. 1004-1007——Table delivered in by Mr. N. Wood, showing the temperature of return air in several collieries, *Rep.* iii. *App.* 170.——*See* also *Atmosphere.*

Tests of Ventilation. Manner in which witness tests the ventilation of mines on his visits of inspection, *Mackworth* 677-679.——*See* also *Anemometer. Ventilation.*

Tetlow, Allan. (Analysis of his Evidence.)—Resides at Hurst Carrs, near Ashton-under-Lyne, 3154——Is agent to the Lancashire Association of Miners, and is deputed by them to give evidence before the Committee; experience of witness as a miner, 3155-3164——The ventilation in the small collieries of Lancashire is worse than in the large ones; there is a general complaint against the inefficient circulation of the air, 3165-3167——Evidence on the probability of accidents occurring through carelessness or defective regulation in winding the men up and down the pits; suggestions on this point, 3167-3237——Accidents have arisen through the men not being allowed sufficient time to get out of the box when let down; it should be imperative that the engineman receive some signal from the bottom before he starts the engine back again, 3167-3172. 3182-3200.

Too many men are frequently let down the pit at the same time; the number should be limited to four, 3173-3181. 3202-3215. 3219-3229——The ropes used in lowering the men are frequently very defective from wear, 3216-3218——In the event of any danger arising during the ascent or descent of the men, it is quite practicable to give a signal to the engineman, if the engine is not winding too quickly, 3230-3232——A code of regulations for the better safety and security of the miners should be enforced by the Legislature in every colliery, 3233-3235——Mode in which these regulations might be drawn up and established; it would be difficult at first to strike out a law satisfactory to all parties, 3234-3237——Remarks upon the system of Government inspection; it has been very beneficial in its operation, but does not go far enough; suggestion for the appointment of a certain number of sub-inspectors, who should be practical miners, with ample power of reporting on all matters that require improvement, 3238-3256. 3263-3295. 3332-3339.

Great satisfaction given to all parties in his district by Mr. Dickinson, Government inspector; many evils have been remedied by his suggestions, 3243-3248——Necessity of a sufficient number of inspectors, who should traverse the remote workings of every pit, and point out any evils that existed; if these were not remedied, he should report them to the inspector, 3249-3251——If the recommendations of the inspector were not attended to, he should report the same to some central Board in London, who should have power, after investigation, to close the mine, 3252-3262——Satisfaction of the miners with the Report of the Committee of 1852, more especially with the recommendations for the appointment of sub-inspectors, 3263. 3305, 3306——The sub-inspectors should be appointed by Government, through some central Board, 3264-3266——Remarks as to the class of men most suitable for sub-inspectors; opinion that selections from practical working colliers are the most competent that can be made, and the most likely to give satisfaction to all parties, 3267-3279. 3282, 3283. 3287-3292.

The central Government Board should consist of men well qualified to investigate existing evils, and to remedy the same; it would be an advantage if they had a practical knowledge of mining, 3280-3286——Opinion that miners would easily be found quite competent to the duties of sub-inspectors, 3287, 3288. 3332-3334——Recommendation that the sub-inspectors be well paid for their services, 3289——All that is wanted for the purpose of improving the present state of collieries, and securing greater safety, is a thorough determination on the part of Government to effect that object, 3290——With respect to ventilation, the miners do not demand the adoption of any particular system, but consider that all collieries should use either the furnace or the steam-jet; natural ventilation cannot be trusted to, 3296. 3330, 3331——A proper circulation of air throughout all parts of the mine is indispensable, 3297, 3298——A mine cannot be well ventilated without splitting the air, 3299-3301.

Due care should be taken to keep the air-ways in proper order and of a sufficient size; there cannot be too much air in a mine, 3302-3304——As an extra safety, in addition to proper ventilation, the use of the safety-lamp should be made compulsory in all fiery mines, 3307-3311——Recommendation of the practice adopted in a colliery of Messrs. Lees, Jones, & Booth, for the purpose of clearing the goaves of the noxious air, 3312-3315——It is much better to expel the foul air from the goaves than to attempt to wall it in, 3317, 3318——A good current of air should at all times circulate close up to the face of the goaves, 3319——With regard to accidents from falls of roofs, it is better for the miners to set their own timber and place the props than for the deputies to do so, 3320-3321——In Lancashire sufficient timber is generally supplied for the purpose of standing the roofs, 3322, 3323.

The present system of coroners' juries is not satisfactory; they should be partly composed of men thoroughly conversant with the nature of a coal pit, 3324-3329——Suggestion for the establishment of schools for the use of colliers and their children; beneficial

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beneficial results that would arise therefrom, 3335-3339——Further reference to the inefficiency of the ventilation in some mines; the health of the miners is very prejudicially affected by the existence of black damp, 3340-3344——How far the miners would be content with less wages, if the ventilation were better; improved ventilation would produce economy in the general working of a mine, 3345-3348——The miners would not object to contribute from their wages towards the support of schools, but might expect the same assistance from Government as is afforded to factory schools, 3349-3355——The children of miners are now allowed by the Legislature to be employed in collieries when they attain the age of ten; in altering this law, witness would suggest that twelve rather than fourteen years of age be the limit; this alteration would be well received by the miners, 3351, 3352. 3356-3360.

Tyne Main Colliery. Details with respect to the Tyne Main Colliery, ventilated by the furnace, forming an economical comparison between the ventilation of that and of the Eagles' Bush Colliery, where the first of Struvè's ventilators was erected; the Tyne Main Colliery was lately experimented upon by Mr. N. Wood in the most careful manner, and it is from his data that witness gives the economical position of the ventilation of that colliery, *Mackworth* 1439-1459——Remarks on the powerful ventilation used in Tyne Main Colliery; about eighty cubic feet of air per minute is supplied to each man; this is vastly more than sufficient, *Wood* 3456-3468——Objection to the experiments with the steam jet at the colliery; cylinders were used, but were much too large in proportion to the size of the jets, *Gurney* 4273-4279——Experiments made at Tyne Main Colliery to determine the actual as well as the relative powers of the furnace and the steam jet, *Rep.* iii. *App.* 131, 132. 142-144. 147, 148. 151 *et seq.*

U.

Ubberley Colliery. See *Staffordshire.*

Under-viewers. Observations with respect to the qualifications of the under-viewers; many of this class are quite unfit for the office, *Jude* 2002-2012.

See also *Viewers.*

Up-cast Shaft. With regard to the up-cast shaft, there is no doubt that it is advantageous for it to be bricked from top to bottom; a furnace not working into a bricked shaft is not in a condition to produce the best effect, *Dickinson* 164-173.

See also *Ascensional Ventilation.* *Furnace Ventilation,* 1.

Upton and Roberts's Lamp. See *Roberts's Lamp.*

V.

Velocity of Currents. Observations as to the velocity of the currents of air that should be kept in motion in every working part of a colliery, *Mackworth* 842-851——Greatest velocity of air obtained in the experiments with the steam jet at Seaton Delaval; the measurements were taken twice with numerous checks to produce accuracy, *Dickinson* 987. 994-1007——Remarks as to the velocity of the air going up the pit at Seaton Delaval, *Forster* 4534-4536——Return, by Mr. N. Wood, of experiments with safety-lamps at Killingworth and Crookbank collieries, to test at what velocity in an explosive mixture of fire-damp and atmospheric air the flame may be passed through the wire gauze, *Rep.* iii. *App.* 173-175.

Vena Contracta. Explanation of the *vena contracta*; *Gurney* 4158, 4159.

Ventilation. Opinion that a perfect system of ventilation is the most important point with regard to the economical and proper working of a colliery, *Dickinson* 403, 404. 1332-1335; *Mackworth* 635-637——Possibility of putting a fiery pit in such a condition as to render it absolutely safe, *Mackworth* 839-841; *Jude* 2086. 2093-2099——Necessity for all coal mines being ventilated; in no case ought the men to be allowed to work where there is not sufficient air to support a candle burning freely, *Dickinson* 1157-1168——There are no means by which the inspectors can know what ventilation is going on during their absence between the visits of inspection, nor does witness know of any means by which this could be accomplished, *ib.* 1186-1208——The quantities of ventilation in the north of England in the larger collieries is three times as much as in the largest collieries in Belgium, *Mackworth* 1503——Remarks as to the means by which ventilation is produced; it is not precisely correct to say that it is the height of the heated column of air which produces ventilation, *ib.* 1560.

Observations as to the most effective mode of measuring the effective ventilation of a colliery, *Mackworth* 1562-1564——The mines in Northumberland and Durham are not in a better condition as to ventilation than they were in 1849, *Jude* 1693-1696——

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What the miners principally want is sufficient ventilation; this can only be enforced by frequent inspection, *Jude* 1864–1870——It is to the interest of the proprietor that the mine should be kept in an efficiently ventilated state, as the loss from an explosion is very great; witness attributes the neglected state of the mines in the north of England to false economy, *ib.* 2075–2084——With respect to ventilation, the miners do not demand the adoption of any particular system, but consider that all collieries should use either the furnace or the steam jet; natural ventilation cannot be trusted to, *Tetlow* 3296. 3330, 3331.

Objections to any recommendation by the Committee of the general adoption of a particular system of ventilation; the coalowners under the supervision of the inspectors should adopt whichever system they considered most conducive to safety, *Wood* 3574, 3575——The particular mode of ventilation should be left to the coalowners, the inspectors seeing that sufficient air was provided and properly distributed, *Blackwell* 3943——General law concerning the ventilation, lighting, and employment of gunpowder in the operations of mining, especially in coal mines subject to fire-damp, *Rep.* i. *App.* 138–140——Paper contributed by Mr. Nicholas Wood to the North of England Institute of Mining Engineers, showing the result of experiments on the relative value of the furnace and the steam-jet in the ventilation of coal mines, *Rep.* iii. *App.* 115–167.

See also *Airways. Anemometers. Artificial Ventilation. Ascensional Ventilation. Atmosphere. Brattices. Crossings. Currents of Air. Distribution of Air. Doors. Escapes of Gas. Expense of Ventilation. Experiments. Furnace Ventilation. Goaves. Health of Miners. Hetton Colliery. Inspection of Mines. Legislation. Mechanical Ventilators. Miners. Natural Brattice. Seaton Delaval Colliery. Shafts. Steam-jet Ventilation. Supply of Air. Tests of Ventilation. Wages. Water Gauge. Wood, Mr. Working of Mines.*

Viewers. Opinion that all collieries ought to be superintended by viewers, according to the system which has been found so effectual in the north of England, *Mackworth* 1636. 1654–1657. 1677–1681——The principal man or manager in a mine in the north of England is called the head viewer, and has an under viewer for his assistant, *Jude* 1844, 1845——The principal viewers are generally a superior class of men in the north of England, *ib.* 1999–2002——The viewers in Yorkshire are less educated than those in the north of England, *Blackwell* 4005——The head viewer incurs immense responsibility, and is liable to great blame if he does not take every precaution to preserve the lives of his men, *Forster* 4618–4620.

See also *Managers of Collieries. Rules and Regulations. Under Viewers.*

W.

Wages. Workmen are disposed to work for less wages in mines that are notoriously well ventilated than in mines that are the contrary, *Jude* 2085——How far the miners would be content with less wages if the ventilation were better; improved ventilation would produce economy in the general working of a mine, *Tetlow* 3345–3348.

See also *Education. Schools*, 2.

Wallsend Colliery. Return by Mr. N. Wood of experiments at Wallsend Colliery on 28 June 1853, to test the merits of various safety-lamps, *Rep.* iii. *App.* 175, 176.

Warren Vale Colliery. Reference to an accident in December 1851, at Warren Vale Colliery, Barnsley, by which 50 persons were killed, *Blackwell* 4131.

Washington Colliery. Paper delivered in with respect to an accident at Washington Colliery, Durham, in August 1851, by which 35 lives were lost; five-sixths of these perished from after-damp, *Blackwell* 4131.

Waste-men. The number of waste-men has been considerably reduced since the introduction of the Davy lamp, *Jude* 1911–1916.

Water Gauge. The best gauge of the ventilating power, and that most commonly used, is the water gauge, *Dickinson* 1087——The greatest extent of variation of the water gauge that witness has ever known by the furnaces has been two inches, *ib.* 1088——Observations as to the extraordinary variations produced on the water gauge with the steam-jet; reference to the experiments which took place at the Polytechnic last year, with the jet, *ib.* 1089–1099——Witness has no reliance upon the water gauge, he prefers the anemometer, *ib.* 1103–1107——Observations relative to the water gauge; objections to forcing the air beyond a certain height of water gauge, either by means of the furnace or the steam jet, *Wood* 3428–3441——The water gauge is a correct measure of the drag or resistance of the air round the workings of the mine, but it is not a correct measure of the power of the ventilation, as there are other resistances to be considered in ascertaining that point, *ib.* 3492–3495——The greatest disturbance of the water gauge produced by the steam jet, in the experiments by witness, was 1·1 inch; dimension of the boilers and area of the grates that were used on this occasion; opinion that the water gauge cannot be

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be disturbed to a greater extent by any different arrangement of the jet, *Wood* 3496-3503. 3515-3524. 3565-3567.

The water gauge can with difficulty be disturbed by the furnace to the extent of three inches, *Gurney* 4155, 4156.——Remarks on Table No. 21 of Mr. Wood, in which he attributes a certain slight disturbance of the water gauge, over and above that produced by the furnace, to the extra power of the steam jet; evidence to the effect that there was no action of the steam jet on this occasion, and that the increase attributed to the jet was due to the temperature, *ib.* 4211-4272. 4286-4292.——Remarks relative to the water gauge, at Seaton Delaval colliery, *Forster* 4442-4445. 4489, 4490.——Observations generally of Mr. N. Wood, upon the subject of the water gauge, *Rep.* iii. *App.* 131.—— Experiments made to determine the power required to produce different velocities of currents of air in coal mines ascertained by the height of water guage, *ib.* 152.

Widows and Orphans. In some cases in Northumberland and Durham, it is the practice to allow the widow of a miner killed by accident a house and coal free for life, but witness cannot say that the practice is universal, *Dickinson* 1405-1410.——A national fund should be established for the support of the widows and orphans of those who meet with their deaths by accidents, and for the aged; this fund should be provided by contributions from the miners, and should be rendered imperative by Act of Parliament, *Henderson* 2444-2458.——Difficulty of establishing a national fund from the earnings of the miners towards the support of the widows and orphan children, *Swallow* 2902-2907.

See also *Benefit Societies.* *Damages at Law.*

Winding up and down of Miners. See *Ascent and Descent of Miners.*

Wire Gauze Lamps. It was found impossible to pass the flame of fire-damp through the Davy and other wire gauze lamps, *Wood* 3741-3746. 3808.

See also *Davy Lamp.* *Safety Lamps*, 2.

Wood, Nicholas. (Analysis of his Evidence.)—Is extensively engaged as a coal viewer and manager of collieries 3361.——Since the termination of the Committee of 1852, witness has tested the efficiency of the steam-jet; the experiments were made with the utmost fairness; neither Mr. Forster nor Mr. Goldsworthy Gurney were present, though invited to attend, 3362-3364.——Evidence in detail with respect to experiments with the steam-jet and the furnace at the Hetton Colliery; result of these experiments; papers handed in in illustration thereof, 3365-3443.——The Hetton Colliery is 900 feet in depth, and the workings extend over an area of upwards of 2,000 acres, 3365-3367.——Different systems of ventilation adopted by witness collectively and separately, in order to arrive at a correct estimate of the force of the steam-jet; size and number of the jets used; quantity of cubic feet of air per minute sent in circulation under the different systems, 3365 *et seq.*——The airways travelled under the experiments extend over 97 miles, 3370-3373. 3442.

Experiments with the steam-jet on 29, 30, and 31 October, and on 13 November 1852, produced respectively the same results, and prove, generally, the inferiority of the steam-jet to the furnace; alteration in the size of the jets used on these occasions, 3374-3393. 3405-3409. 3413.——The power of the Hetton furnaces could be increased from 1·20 water gauge up to 1·75; it is impracticable to attain a water gauge of three inches, 3394-3397.——The ordinary working of the furnace should be very much below the power to which in case of emergency it might be worked, 3397-3400.——On 3 July 1853, witness made another experiment with the steam-jet; quantity of cubic feet of air per minute produced by the boiler fires, and by 37 jets during a trial of 12 hours, 3400-3413.——Result of counter-experiments with the furnace alone, as against the steam-jet, 3414-3417.——Comparison of the consumption of coals in the use of the furnace and of the steam-jet; the balance is rather against the former, as the quantity of air with the furnace is greater than with the steam-jet, 3414-3416.——There are three furnaces in use at the Hetton Colliery; one of these, which is nine feet wide, produced about the same velocity of the current and the same quantity of air as the steam-jet, 3414-3416.

Remarks as to the resistance of the drag of the air round the workings, and of the resistance in the shaft and over the furnace, 3418-3422. 3428-3434.——In some respects it is better to have a shaft of a small rather than of a large area, 3421-3427.——Observations relative to the water gauge; objections to forcing the air beyond a certain height of water gauge, either by means of the furnace or the steam-jet, 3428-3441.——All ventilation by mechanical power should be kept within certain limits; there should be a standard of velocity for the furnace and the steam-jet, and any increase of that velocity should be procured by enlarging the airways, having additional shafts, or splitting the air so as to diminish the resistance, 3435-3441.

[Second Examination.]—Further evidence on the subject of the experiments on furnace ventilation in Hetton Colliery; corroboration of witness's statements as to the consumption of coals, by an account of the practical working of the furnace at 17 collieries in the neighbourhood of Newcastle, being the result of an inquiry by Professor Phillips,

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Wood, Nicholas. (Analysis of his Evidence)—*continued.*

3444-3452——As a general rule each furnace will consume three-quarters of a pound of coal per minute for each foot of width, the length of the furnace being about four feet, 3447-3449——With reference to the working power of the coal it may be taken as a general rule that 550,000 cubic feet of air are heated 1° with each pound, 3449——Opinion that four feet is the best length for a furnace, 3450-3452——The power of the furnace depends a good deal upon the depth of the shaft; in applying the furnace to deep mines, a higher water gauge should be used than in small mines with less depth of shaft, 3452, 3453.

A colliery with workings to the extent of 1,000 acres may be thoroughly ventilated with 50,000 or 60,000 cubic feet of air per minute; the quantity of coal worked in such a colliery would be about 120,000 tons a year, 3454-3456——Remarks on the powerful ventilation used in Tyne Main Colliery; about 80 cubic feet of air per minute is supplied to each man; this is vastly more than sufficient, 3456-3468——The existence of noxious air in a mine depends much on the extent of open face at which the men are working; the amount of ventilation should be regulated by the extent of face, 3461-3465——Result of experiments at Killingworth Colliery with the steam-jet and the furnace, showing the greater power of the latter, 3469-3491. 3510-3514.

The water gauge is a correct measure of the drag or resistance of the air round the workings of the mine, but it is not a correct measure of the power of the ventilation, as there are other resistances to be considered in ascertaining that point, 3492-3495——The greatest disturbance of the water gauge produced by the steam-jet, in the experiments by witness, was 1·1 inch; dimension of the boilers and area of the grates that were used on this occasion; opinion that the water-gauge cannot be disturbed to a greater extent by any different arrangement of the jet, 3496-3503. 3515-3524. 3565-3567——Remarks on the principles by which the furnace and steam-jet act; the former acts through the principle of rarefaction, the latter, if placed at the top of the pit, acts mechanically; and if placed at the bottom, by rarefaction, 3504-3514. 3547 *et seq.* ——In the experiments with the steam-jet there was no such thing as the pneumatic flower-pot established, that is, there was no retrograde current down the sides of the jets, 3511-3514——The experiments in ventilation recently made by witness do not militate against those tried by Mr. Elliott in 1849; witness's experiments go farther and show the result due to the mechanical force of the jet, 3525-3529. 3562-3564.

Some errors may have crept into the pamphlet containing an account of the experiments, but witness abides generally by the principles and conclusions therein stated, 3522, 3523——Reference to experiments made by witness at the St. Hilda and Harton Pits, South Shields; the result shows that the power of the steam-jet is inferior to that of the furnace, 3534-3546. 3578-3581——The application of the jet to St. Hilda Colliery was in the first instance judicious and useful; but it was insufficient to clear the pit entirely of bad air, and the furnace was resorted to, 3537-3546——Remarks on the best manner of applying the jet to the ventilation of coal mines; the experiments by witness were conducted in a proper and scientific manner, and he took every care that such should be the case, 3547-3561. 3582-3589——The results of those experiments show that the steam-jet, though it may be useful to a trifling extent, is an uncertain and expensive mode of ventilation, and altogether deficient as a substitute for the furnace, or as an auxiliary thereto, 3568-3573.

Reference to the use of the steam-jet at the collieries of South Hetton and Seaton Delaval, 3569-3572——Objections to any recommendation by the Committee of the general adoption of a particular system of ventilation; the coal owners, under the supervision of the inspectors, should adopt whichever system they considered most conducive to safety, 3574, 3575——Evidence on the subject of a proper distribution of the air round all the workings in a mine; importance of the practice of air-splitting; recommendation of regulators rather than doors for the purpose of splitting the air and effecting its thorough circulation, 3591-3634——Precautions to be taken in the event of explosions, provided regulators supersede the present doors; description of a regulator, 3612-3627.

Reference to the resistance of the air in Crookbank colliery; Paper on the subject delivered in, showing experiments by Mr. Greenwell, 3628——Every miner should have a certain quantity of air, and it should be the duty of the inspectors to see that such is the case, 3632-3634——No colliery should be carried on with merely natural ventilation; some artificial system should be imperative, 3635-3639——Suggestions as to the best means of clearing the goaves of foul air; a partial ventilation of the goaves is extremely dangerous, and is much worse than no ventilation at all, 3640-3655——Recommendation of certain means for the insulation of goaves, so as to carry off any exudation of fire-damp, thereby rendering them perfectly safe, 3642-3649——The Report of the Committee of 1852, as to putting bore holes down on the goaves, is perfectly absurd; the effect would be to send air into the holes, and probably water also, instead of extracting the air out of them, 3650-3654——As a general rule, naked lights should not be carried about in the vicinity of the goaves, 3655——There can be no such thing as a natural bratice; grounds for this assertion, 3656-3658.

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Wood, Nicholas. (Analysis of his Evidence)—*continued.*

Opinion that refuge stalls for the men to fly to in case of explosions are not practicable; remarks in support of this opinion, 3659-3665——The safest place after an explosion is in the face of the bords, where the air is pent up to a certain extent, 3664, 3665——Objections to a recommendation of the Committee of 1852, that there should be a self-registering anemometer in every pit, and that it should be so placed that the inspector, on his periodical visits, might know the rate at which the current of air had been passing through the mine in his absence, 3666–3678——The best regulator is an anemometer placed near the furnace; a record of its state should be reported at short intervals to the manager of the mine, 3668–3673.

Reference to the serious losses inflicted on coal owners by the occurrence of explosions, 3679-3681——Care and attention are the best precautions against accidents from falls of roofs; the deputies are more suitable parties than the workmen to fix the props, 3682-3684——The coal owners generally supply sufficient timber for the purpose of props; it is their manifest interest to do so, 3685–3688——Approval of the suggestion that every abandoned pit should be walled round, or properly secured, so as to prevent accidents, 3689-3692——With respect to falls of stones from pits or shafts in work, it should be the peculiar province of the inspector to see that such shafts are securely walled off, 3693-3695——Remarks as to the occurrence of accidents during the process of winding the men up and down the shaft; they could be wound up with perfect safety at a speed of 300 feet per minute, 3696-3705——Objections to the use of Fourdrinier's cage as being very liable to get out of order, 3706-3708——There would be no practical advantage in having a cover over the top of the pit to prevent the men walking into it, 3709-3713——With respect to the process generally of winding up and down the pit, certain rules should be established on which the inspectors and coal owners should act, 3714-3717.

[Third Examination.]—Evidence on the subject of the furnace limit; remarks to the effect that the same resistance that would cause such limit would equally apply to the steam-jet, or to any mechanical power, 3718-3739——Over a period of 40 years, witness, in using the furnace, has never experienced anything like a natural brattice in practice, 3736–3739——Examination as to experiments made by witness on several safety lamps, in order to test their respective merits, 3740–3828——It was found impossible to pass the flame of fire-damp through the Davy and other wire gauze lamps, 3741-3746. 3808——The Davy lamp did not explode till the wire gauze had attained a brilliant white heat, the lamp being moved at a velocity of 15 feet per second, 3743-3745. 3761-3763. 3809——Result of the experiments on lamps constructed on the principle of admitting a limited quantity of atmospheric air, the security and insulation of the lamp being attained by glass or talc; all these lamps were put out when inserted in an inflammable mixture, 3743-3746. 3752-3759.

The Clanny lamp, which has a copper wire gauze, exploded more readily than the Davy lamp; objection to copper wire, 3747–3749. 3754——Result of experiments on the Eloin lamp; construction of this lamp, 3750, 3751. 3763–3766. 3772-3776——Witness also tested the Stephenson, the Clanny, and Dr. Fife's lamps; result of these experiments, 3763-3765. 3780-3785. 3793-3804——With respect to lamps having a diminished quantity of air entering and feeding the flame, and with the use of glass, there is occasion to have the insecurity of the wire gauze upon the top of them, 3765, 3766. 3803——Opinion that Dr. Glover's lamp combines the two principles of giving the greatest quantity of light, and the greatest safety, more than any other lamp; grounds for this opinion, 3765-3771. 3777-3779. 3787, 3788——As a wire gauze lamp the Davy lamp is the most secure; deficiency of light shown by this lamp, 3772. 3803, 3804——Approval of the principle of a lamp now being constructed by Mr. Hall, of Newcastle, 3777.

Species of top recommended for safety lamps; a lamp with a properly constructed top and two cylinders of glass is the safest, 3786-3789. 3803——Peculiar construction of Mr. Martin Roberts's lamp, which extinguishes the flame in the event of the glass being broken, 3793-3796——Remarks to the effect that witness is convinced by experiments and by practice of the security afforded by safety lamps; suggestions as to the rules and regulations that should accompany their use, 3805-3828——The lamps should be inspected daily by competent persons before they are taken into the mine, 3810-3812——The miner should not be entrusted with a key of the lamp, nor allowed to take the top off, 3813-3815. 3822, 3823——Where safety-lamps are used the collier should not be allowed to smoke, 3816——In all mines doubtfully safe, where lamps are employed, the use of gunpowder should be prohibited, 3817, 3818.

Many accidents have arisen from the use of naked lights, which would not have occurred if the Davy or other safety-lamps had been employed, 3827, 3828——Consideration of the present system of government inspection; evidence showing that it is not conducted upon a proper basis; suggestions for its improvement, 3829-3900——Explanation as to the working of mines in Northumberland and Durham; enumeration

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of the different persons engaged in the management; definition of their duties; number of colliers, &c., employed, 3830-3847. 3892-3898——Opinion that the management of the Northumberland and Durham mines is the most perfect in the kingdom, 3831. 3845, 3846——In those counties the number of accidents is diminishing, whereas in Yorkshire, and the midland districts the reverse is the case; causes to which this is attributable, 3846, 3847——The suggestion to appoint sub-inspectors from practical miners is very objectionable, 3848. 3879-3883.

The only way in which accidents can be prevented is to bring about a superior knowledge, and a greater capacity generally in the managers of the mines, 3848, 3849—— The responsibility of the management should rest exclusively with the managers themselves, and not with the inspectors, 3848——Objection to the sub-inspectors being appointed from the overmen or under viewers, 3849——Suggestion for the formation of mining schools, in which persons can be rendered properly qualified in every way for the management of collieries; mode in which these schools should be supported and conducted, 3849-3860——Sketch of a school proposed by witness to be formed at Newcastle for the efficient training of managers; the coal owners are ready to subscribe towards it, and assistance is expected from Government, the University of Durham, and the Museum of Practical Geology, 3849-3856.

Parties acquiring scientific knowledge in the proposed schools could also obtain practical knowledge by periodical visits to the mines, 3854-3856——In the event of these schools being established, it should be compulsory on the coal owners to employ only such persons as managers or otherwise, who had passed the necessary examinations therein, 3857-3860——Insufficiency of the number of the Government inspectors, 3861. 3899——The suggestions of the inspectors to the coal owners are in effect orders, and are not always duly weighed before being issued, 3862, 3863——The inspectors are generally competent to undertake the duties of their office, 3864——Suggestion that the inspection of mines, like the inspection of railways, become a separate department under the Board of Trade; beneficial working of such an arrangement, 3864 *et seq.*—— Remarks upon the system of Government inspection in Belgium; opinion that its introduction into this country is very desirable, 3866-3870. 3875.

There should not be any intermediate authority between the Board of Trade and the staff of inspectors proposed by witness, 3871——A code of rules and regulations should be determined upon by consultation between the inspectors and the principal viewers and coal owners in the kingdom; these rules should be made the law of the land, and should form the basis of the system of inspection, 3875-3891——The rules proposed by the inspectors who have been examined before the Committee do not go far enough, but are otherwise not objectionable, 3884-3886——Witness cannot suggest any improvement upon the present system of coroners' juries, 3901, 3902——The efficiency of inspection would be increased if an official record were kept of the proceedings before coroners' juries, and of the inquiries of the inspectors themselves, 3901——A better knowledge of the cause of accidents would aid much towards their prevention, 3901——The owners of collieries almost universally subscribe towards schools for their workmen's children, 3903. 3910——It would be a very great hardship on the colliers if their children were not allowed to enter a mine till they were 12 or 13 years old; for purposes of education they should, however, attend school for a certain number of hours weekly, 3903-3905. 3908.

The practice of deducting a small amount from the earnings of the men, and giving them a voice in the management of the schools, has not been found to work well, 3906, 3907——The miners are generally willing enough to subscribe towards their children's education, 3908-3910——Subscriptions are paid by the men towards a fund in the event of sickness, &c., but they would object to provide any fund for the support of their widows and orphans in case of their own accidental deaths, 3912-3916——The colliers in the north of England are improving in intelligence and education; the good effects of this improvement are arguments in favour of a general system of education for the mining districts, 3917-3921——As a body the miners of England are more free from crime than any other class of the population; this may be attributed to the fact of their being under the eye of their masters, and generally removed from the vicinity of large towns, 3922-3924.

Wood, Mr. There is not a single table drawn up by Mr. Wood in which there are not most extraordinary inaccuracies, *Gurney* 4209, 4210——Great pains and labour bestowed by Mr. Wood on his experiments; whether the steam jet or the furnace is the best mode of ventilation; all these experiments and inquiries will do a great deal of good, as tending to improve ventilation in collieries in the north of England, *Forster* 4500-4503—— There are certain discrepancies in Mr. Wood's tables and accounts of his experiments, which require some explanation, but the discrepancies are not such as to invalidate the general truth of the tables, *ib.* 4538-4556.

Working

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Working of Mines. Advantage of driving the galleries to the extremity of the mine and working the coal backwards, as it ensures a permanent air-way at all times; witness would particularly recommend this system of working in fire-damp mines, *Dickinson* 11–24——Witness would not recommend the Legislature of this country to enforce either the system of long wall work or stall and pillar work; it would be impossible to say a proprietor should work his coal in this or that manner, *Mackworth* 814, 815——Explanation as to the working of mines in Northumberland and Durham; enumeration of the different persons engaged in the management; definition of their duties; number of colliers, &c. employed, *Wood* 3830–3847. 3892–3898——If the air is not carried to the extreme of the workings, the pit cannot be well ventilated, *Forster* 4498.

See also *Belgium.* *Closing of Mines.* *Long Work System.* *Pillar and Stall System.* *Seaton Delaval Colliery*, 1.

Y.

Yorkshire. Imperfect state of the ventilation in the Yorkshire mines, *Blackwell* 4004.

See also *Barnsley District.* *Viewers.*